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HYBRID LTA VEHICLE CONTROLLABILITY AS AFFECTED BY THRUSTER MAGNITUDE AND SPACING

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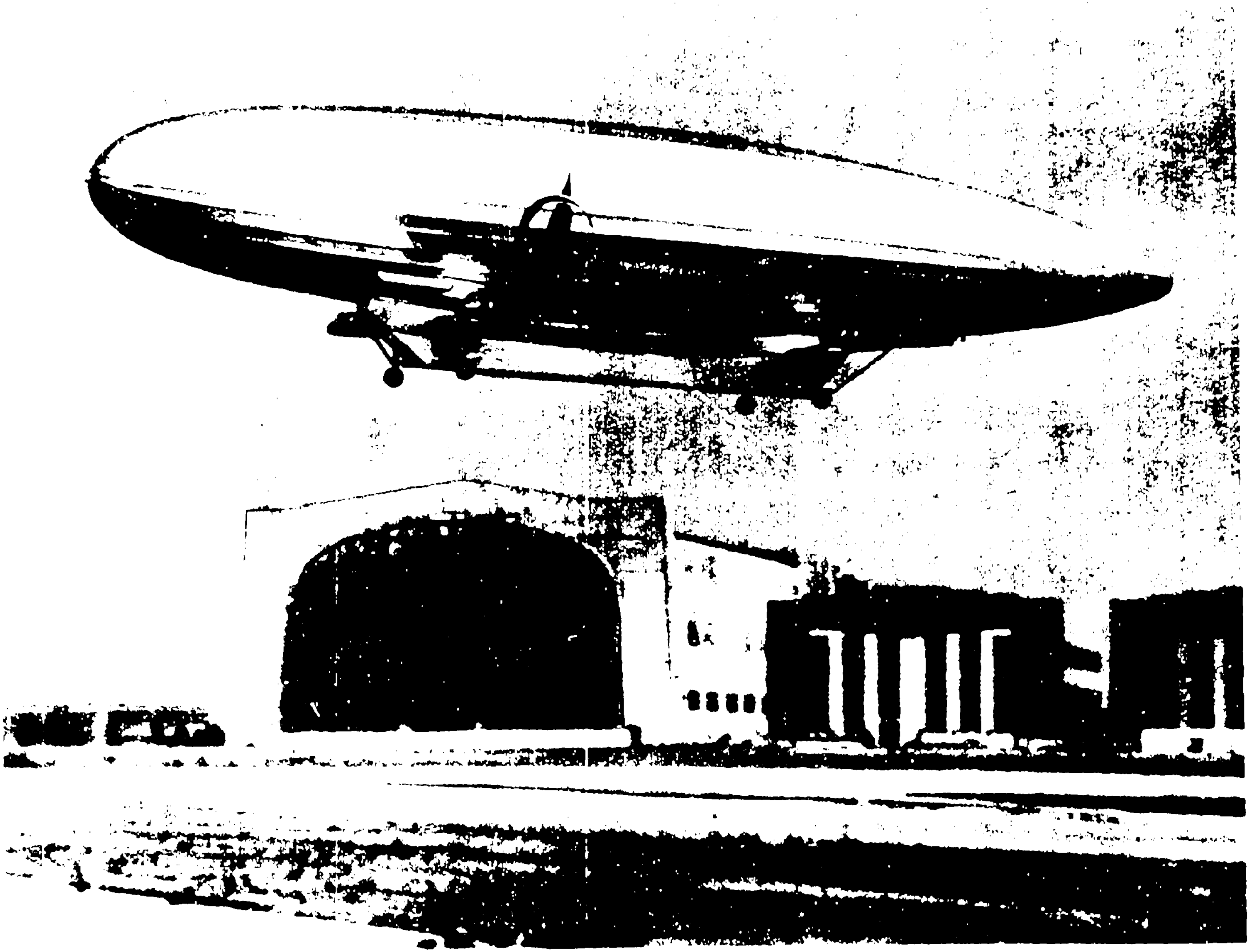
Results of an analytical investigation are presented which show the effects on low speed maneuverability of several geometric and dynamic parameters of a hybrid lighter-than-air (LTA) vehicle. Most significant of these parameters are: ratio of static lift to gross weight; relative spacing of vertical thrusters; relative amount and direction of available horizontal thrust. The analysis, which is based on nine "point designs" representation of real

vehicles, takes into account the increased moment of inertia associated with increased spacing of the dynamic thrusters.



PIASECKI HELI-STAT, HEAVY VERTICAL AIR LIFTER

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1. SUMMARY

An investigation has been conducted on the effect of geometric and dynamic parameters on the maneuverability of a hybrid lighter-than-air (LTA) vehicle, notably the ratio of longitudinal rotor spacing to overall length, and the ratio of static-lift to gross-weight. Other parameters considered were airspeed, angle of sideslip, and amount of horizontal thrust.

The study was conducted on 4 variations of 9 different vehicle designs forming a matrix with 36 variations in the geometric and dynamic parameters.

A qualitative summary of the effects of these parameters is shown in the chart, Fig. 1. More detailed discussion of these separate effects is given in Section 5, together with graphs showing the various functional relationships.

FIG. 1 EFFECTS OF GEOMETRIC AND DYNAMIC PARAMETERS ON MANEUVERABILITY OF LTA VEHICLES°

PARAMETER / MODE OF ACCELERATION	INCREASING LONGITUDINAL ROTOR SPACING	INCREASING RATIO OF STATIC LIFT TO GROSS WEIGHT	INCREASING RATIO OF HORIZONTAL THRUST TO ROTOR LIFT	INCREASING AIRSPEED	ANGLE OF SIDESLIP
LONGITUDINAL	NO INFLUENCE	DECREASES	INCREASES	SLIGHT DECREASE	NOT INVESTIGATED
PITCH	INCREASES	DECREASES	NOT APPLICABLE	SLIGHT DECREASE	NOT INVESTIGATED
LATERAL TRANSLATION	NO INFLUENCE	DECREASES	NO INFLUENCE	DECREASES	NOT INVESTIGATED
ROLL	NO INFLUENCE	DECREASES	NO INFLUENCE	DECREASES	NOT INVESTIGATED
YAW	DECREASES	DECREASES	INCREASES	DECREASES AT CRITICAL YAW ANGLES	MINIMUM AT APPROX. 45 DEGREES

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3. INTRODUCTION

The ability of Lighter-Than-Air-Vehicles utilizing large fractions of rotor lift to perform precision hovering maneuvers depends on the relative magnitudes of the dynamic thrust forces and their moments, the overall moment of inertia, and the aerodynamic hull moments. Design studies show the desirability to keep the overall length of the vehicle to a minimum for a given payload capability, in order to reduce surface wetted area, structural weight, cost, and mooring space requirements.

Hovering maneuverability is directly related to the ratio of static to rotor lift.

The study effort herein is directed toward reduction of weight empty and construction costs by reduction of rotor-spacing/overall-length ratio, and increasing the static/rotor lift ratio.

Calculations of the controllability for various hybrid configurations with reduced ratio of rotor spacing to overall length are presented.

4. METHOD OF ANALYSIS

The objective of this investigation was to determine the effects on controllability of hybrid LTA vehicles of buoyancy ratio and longitudinal rotor spacing ratio. These two quantities are both dimensionless ratios, and hence a knowledge of their influence can be applied to a wide variety of designs. However, consideration of other design aspects has shown that several other design variables can have a considerable influence, and if not held constant in the investigation, could mask the influence of buoyancy ratio and rotor spacing ratio. Indeed, these other design variables have a direct bearing on the vehicle mass distribution (thus moment of inertia) and on the effectiveness of available control forces. These aspects are discussed below.

Size of Aerostat

Assume that a comparison is to be made between two LTA vehicles of the same displaced volume (e. g. 1,500,000 cu. ft.), the same static lift (e. g. 94,000 lb.), and the same rotor spacing ratio (e. g. rotor spacing is 50% of overall length). However, let the fineness ratios of the two vehicles differ, so that vehicle A is twice as long as vehicle B, and that both vehicles have a moment of inertia distribution which is approximately uniform longitudinally. Then, since

moment of inertia in pitch or yaw varies as L^2, where L is vehicle length, the ratio of moment of inertia will be

$$\frac{I_A}{I_B} = (2)^2 = 4$$

$$\text{or } I_A = 4\, I_B$$

Control moments which can be developed are equal to the product of the rotor thrust component about the particular axis (assumed the same for both vehicles) times the longitudinal distance from rotor to c.g. Since vehicle A is twice as long as vehicle B, and both have the same rotor spacing ratio, it follows that vehicle A can develop a yawing or pitching moment, M, of twice that of vehicle B.

$$M_A = 2\, M_B$$

The ratio of control effectiveness of the two vehicles, is measured by angular acceleration, α, which is

$$\alpha = \frac{M}{I}$$

$$\frac{\alpha_A}{\alpha_B} = \frac{\dfrac{M_A}{I_A}}{\dfrac{M_B}{I_B}} = \frac{\dfrac{M_A}{M_B}}{\dfrac{I_A}{I_B}}$$

Substituting $\dfrac{I_A}{I_B} = 4$ and $\dfrac{M_A}{M_B} = 2$

$$\frac{\alpha_A}{\alpha_B} = \frac{2}{4} = 0.5$$

Vehicle A can develop one-half the angular acceleration of vehicle B. Thus differences in shape, alone, can mask the effects of either buoyancy ratio or rotor spacing ratio.

A similar situation develops if the fineness ratio is maintained constant, for two vehicles of different overall size, even if rotor spacing ratio and buoyancy ratio are held constant. Assume that vehicle C has twice the aerostat volume, twice the static lift, and twice the dynamic lift of vehicle D, but the same relative shape (fineness ratio).

The ratio of lengths, L , will be approximately

$$\frac{L_C}{L_D} = (2)^{1/3}$$

The ratio of moments of inertia, I , will be

$$\frac{I_C}{I_D} = 2 \left((2)^{1/3}\right)^2 = (2)^{5/3}$$

The ratio of control moments, M , will be

$$\frac{M_C}{M_D} = 2 (2)^{1/3} = (2)^{4/3}$$

The ratio of control effectiveness, or angular acceleration, will be

$$\frac{\alpha_C}{\alpha_D} = \frac{\frac{M_C}{I_C}}{\frac{M_D}{I_D}} = \frac{\frac{M_C}{M_D}}{\frac{I_C}{I_D}} = \frac{(2)^{4/3}}{(2)^{5/3}} = (2)^{-1/3} = .79$$

Because of this size effect, the investigation dealt with vehicles which all have the same displaced volume and shape.

Ballonet Air Volume

The volume of air in the aerostat ballonets, especially when the ballonets are located in the extreme bow and stern for effective trim control, will have a major effect on pitch and yaw moments of inertia. For example assume two LTA vehicles of identical shape and displaced volume (e.g. 1,500,000 ft.^{3}), with the same rotor spacing (hence the same rotor spacing ratio), and operating at the same static lift/gross weight ratio (e.g. 0.5).

Suppose vehicle E is fully inflated with helium, and thus has a static lift of 94,000 lb. Since we have assumed a static lift/gross weight ratio of 0.5, the gross weight will be 188,000 lb., and the rotor lift will be 94,000 lb. The empty weight will probably be of the order of 65,000 lb., and the resulting useful load will be 123,000 lb. The latter will tend to be longitudinally concentrated near the vehicle c.g. and contribute relatively little to the overall vehicle moments of inertia in pitch and yaw.

Now let vehicle F be only 86% inflated with helium with the remaining 14% of the volume consisting of air in forward and aft ballonets. This is representative of a design pressure height of 5,000 feet, where the helium

would expand to fill the entire volume, and the ballonets would be fully collapsed. This vehicle would have a static lift of 86% of 94,000 lb., or 80,840 lb., and a gross weight of 161,680 lb., since we are holding the static lift/gross weight ratio constant at 0.5. Since the empty weight should be the same as for vehicle E, the useful load will be 96,680 lb., a reduction of 26,320 lb. compared to vehicle E. The air in the ballonets has a mass in excess of the displaced helium (expressed in pounds instead of slugs) equivalent to 14% of 94,000 lb., or 13,160 lb. A comparison of vehicles E and F is shown below:

	Units	Vehicle E	Vehicle F	Difference
Displaced Volume	cu. ft.	1,500,000	1,500,000	
Pressure height	ft.	S.L.	5,000	
Air in Ballonets	cu. ft.	0	210,000	
Air in Ballonets	lb.	0	13,160	13,160
Static Lift	lb.	94,000	80,840	
Rotor Lift	lb.	94,000	80,840	
Gross Weight	lb.	188,000	161,680	
Empty Weight	lb.	65,000	65,000	
Useful Load	lb.	123,000	96,680	-26,320

Vehicle F has a useful load which is 26,320 lb. less than Vehicle E. However, since the useful load is more or less concentrated near the c.g., its effect on moment of inertia is small. On the other hand, vehicle F has 13,160 lb. of air contained in ballonets located at its extremities. This will cause a significant increase in pitch and yaw moments of inertia. At the same time, the rotor lift (which is vectored for yaw control) has been reduced by 14%. Thus these two vehicles, with the same size, shape, static lift/gross weight ratio, and rotor spacing ratio, will be significantly different in controllability.

To avoid this influence, the investigation dealt with a standardized pressure height of 5,000 feet, equivalent to a sea level helium inflation of 86%, with 14% of the volume consisting of air in ballonets located at the bow and stern.

Rotor Diameter

For reasons discussed above, the investigation has dealtwith hybrid vehicles, all of which have aerostats of the same volume, shape, and static lift. It follows that variation of the static lift/gross weight ratio must involve variation of gross weight, and hence rotor lift. The question then arises as to how best to treat the variation of rotor thrust.

One method would be to maintain a constant disk loading, allowing the rotor diameters to increase as the rotor lift increases. From a design standpoint, this means that the minimum longitudinal rotor spacing which can be investigated would be governed by clearance considerations with the largest rotor, which would unduly restrict the range of rotor spacing ratios to be investigated. For this reason, the rotor diameter was held constant, and the disk loading allowed to increase with increased rotor lift. This scheme has the additional valuable feature that variation of rotor lift is representative of operating a given vehicle at various loading conditions, including minimum flying weight, thus providing greater insight into the effect of payload variation on flying qualities in a given vehicle.

Vectoring Angle of Main Rotor Thrust

Vectoring of the thrust of the lifting rotors of the hybrid LTA vehicle is the primary means of providing control forces and moments for translational and rotational motion in all axes. The term "vectoring" includes variation in the size of the vector as well as in its direction. Clearly if the maximum amount of vectoring is permitted to be different in two vehicles which are otherwise identical, then their manœuverability will be different. It is essential to maintain a uniform concept for maximum vectoring among all

the vehicles under consideration. For angular deflection of the thrust vector a maximum value of 12 degrees was maintained, longitudinally and laterally (independently). This value is representative of maximum longitudinal and lateral cyclic pitch control of typical helicopter rotors. The maximum magnitude of differential thrust was plus or minus 30% of the maximum steady-state value (typical for tandem helicopters). However, the configurations with static-lift/gross-weight ratio of .85 can be considered representative of the configurations with a .609 ratio when the latter are flying with about 50% payload. (The smaller payload results in a smaller gross weight, which in turn means a larger ratio of static-lift/gross weight.) Therefore, an additional series of cases was calculated, using the weights and inertias of the .85 designs, but the control forces of the .609 designs.

Horizontal Thrusters

When the hybrid LTA vehicle is operating at a relatively low static lift/gross weight ratio, and hence a substantial amount of rotor lift, the latter forces can be vectored for propulsion and control about all axes (see previous paragraph). However, when the vehicle is operating at a high static lift/gross weight ratio (above about 0.8), and hence small values of rotor thrust, then the force vectors become too small to be effective, even when vectored to large deflection angles.

A solution to this situation is to use horizontal thrust units, such as propellers, mounted to produce thrust

vectors directed in a variable azimuth, but in a horizontal plane. These units can be driven from the same powerplants or from their own separate powerplants. For the purpose of this controllability study it does not matter. The vehicles investigated were considered to be provided with thrust means capable of producing horizontal forces in the range of 3% to 100% of main rotor maximum steady-state thrust. The specific amount constitutes an additional variable in the study matrix (see "Methodology," the next subsection of the report).

METHOD OF ANALYSIS (Cont'd)

Methodology

The first step required in the analytical study was to establish a matrix of point designs covering a broad interval of rotor spacing ratio and buoyancy ratio (static lift to gross weight ratio). The point designs have been selected with due consideration given to the design aspects discussed above, and their major characteristics are listed in the chart, Fig. 2.

The model designation code contains the most significant feature of each design. The numeral before the "/" is the longitudinal rotor spacing, in feet. Associated with each of the three rotor spacings is the letter A, B, or C, primarily to aid the reader's memory. The decimal fraction after the "/" is the ratio of static-lift to gross weight, of which there are three. Thus Fig. 2 shows nine point designs, in addition to the reference design, model 97-1 from Ref. 1.

Analyses were carried out for each of the nine matrix design points, which were further subdivided with regard to the amount of horizontal thrust assumed. Four constant ratios of horizontal thrust to main rotor thrust were used: .03, .125, .50, and 1.00, thus making 36 distinct design points. Fig. 3 is a composite three-view drawing, showing, the assumed aerostat shape and the three different locations of the propulsors (helicopters).

FIG. 2 MATRIX OF CONFIGURATIONS OF HYBRID LTA VEHICLES

	UNITS	REF.MODEL 97-1			
VOLUME	CU.FT.	2,900,000	1,500,000	1,500,000	1,500,000
OVERALL LENGTH, AEROSTAT (L)	FT.	384	240	240	240
LONGIT. DIST. BETWEEN ROTORS (X_R)	FT.	295.25	76	130	184
LONGIT. RTR. SPACING RATIO (X_R/L)	-	.769	.317	.542	.767
MAX. DIAM., AEROSTAT	FT.	124	103	103	103
STATIC LIFT AT 5,000 FT.PRESS.HT.	LB.	140,800	80,900	80,900	80,900
AUX. HORIZONTAL THRUST (MIN/MAX)	LB.	-	5,900/19,700	5,900/19,700	5,900/19,700
MODEL DESIGNATION	-		C-76/.85	B-130/.85	A-184/.85
STATIC LIFT/GROSS WT. RATIO	-		.85	.85	.85
GROSS WEIGHT	LB.		95,180	95,180	95,180
ROTOR LIFT, TOTAL	LB.		14,280	14,280	14,280
ROTOR THRUST, EACH	LB.		3,570	3,570	3,570
ROTOR DIA./DISK-LOADING	FT/PSF		56/1.45	56/1.45	56/1.45
MODEL DESIGNATION	-	97-1	C-76/.609	B-130/.609	A-184/.609
STATIC LIFT/GROSS WT. RATIO	-	.438	.609	.609	.609
GROSS WEIGHT	LB.	321,600	132,900	132,900	132,900
ROTOR LIFT, TOTAL	LB.	180,800	52,000	52,000	52,000
ROTOR THRUST, EACH	LB.	45,200	13,000	13,000	13,000
ROTOR DIA./DISK-LOADING	FT/PSF	72/11.10	56/5.28	56/5.28	56/5.28
MODEL DESIGNATION	-		C-76/.291	B-130/.291	A-184/.291
STATIC LIFT/GROSS WT. RATIO	-		.291	.291	.291
GROSS WEIGHT	LB.		277,940	277,940	277,940
ROTOR LIFT, TOTAL	LB.		197,040	197,040	197,040
ROTOR THRUST, EACH	LB.		49,260	49,260	49,260
ROTOR DIA./DISK-LOADING	FT/PSF		56/20.0	56/20.0	56/20.0

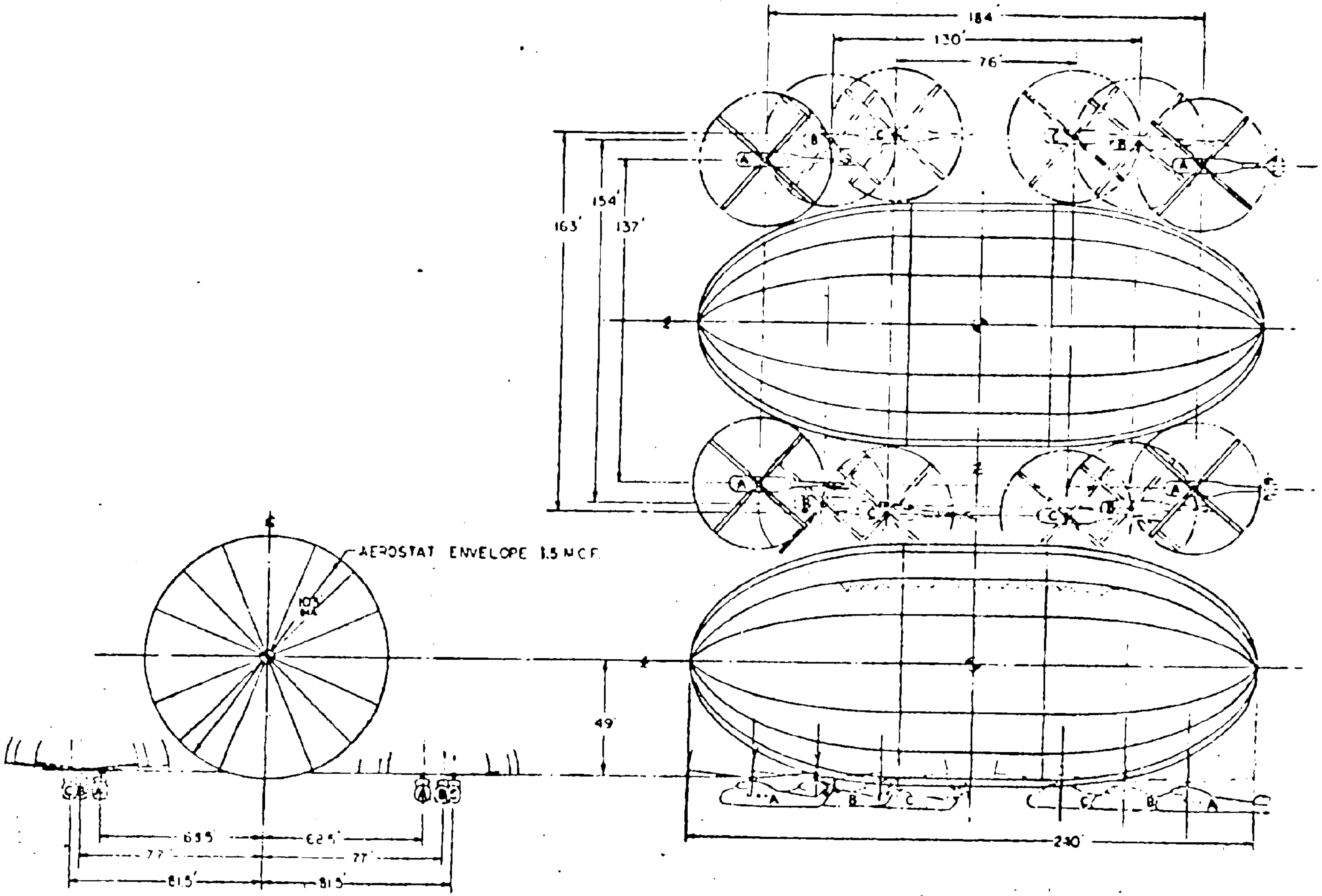


FIG. 3 MATRIX OF DESIGNS FOR STUDY OF HYBRID LTA CONTROLLABILITY (DWG. 97X0066)

Next, the following inertial and aerodynamic properties were determined for each point design.

1. Weight breakdown, including aerostat propulsors, interconnecting structure, and payload, and c.g.

2. Mass, including components of item 1, above, plus enclosed air, helium, and additional apparent mass.

3. Moments of inertia in pitch, roll, and yaw, including additional apparent inertia.

4. Drag at airspeeds of 15, 25, and 35 knots, and at sideslip angles of 0, 30, 60, and 90 degrees.

5. Aerodynamic yawing moments at airspeeds of 15, 25, and 35 knots, and sideslip angles of 0, 30, 60, and 90 degrees.

6. Control forces and moments available from the main and auxiliary rotors.

At each sideslip angle and speed considered, the control forces necessary to trim the vehicle were calculated. Finally, maximum accelerations were calculated based on maximum control forces available after subtracting those required for trim. Controllability analyses were made for the following flight conditions.

1. Acceleration in pitch and in forward translation (independently), at zero sideslip angle, zero pitch angle, and forward speeds of 0, 15, 25, and 35 knots.
2. Acceleration in roll, from trimmed roll attitude, at sideways velocities ($\beta = 90$ degrees) of 0, 15, 25, and 35 knots. Since longitudinal rotor spacing has no effect on lateral flight at $\beta = 90$ degrees, except for a minor effect on lateral drag, this analysis was carried out for only one value of rotor spacing.
3. Acceleration in lateral translation, after achieving the maximum roll attitude, at sideways velocities ($\beta = 90$ degrees) of 0, 15, 25, and 35 knots. Again, this was done at only one value of longitudinal rotor spacing.
4. Acceleration in yaw, from trimmed attitude, at speeds of 0, 15, 25, and 35 knots, and at sideslip angles of 0, 30, 60 and 90 degrees.

In all cases, the acceleration was in the direction with least control remaining. Thus, if the vehicle was trimmed in a right roll (to maintain right sideslip), the least roll control remaining was to roll further to the right. If trimmed in yaw to maintain a sideslip angle (other than zero) at a constant

airspeed, the least yaw control remaining was to reduce the sideslip, since the vehicle was unstable in yaw, tending to yaw to a greater sideslip angle unless resisted by control forces.

Sources of control forces and moments are shown in Fig. 4.

RESULTS OF ANALYSES

Longitudinal Acceleration

Fig. 5 shows maximum longitudinal acceleration capability plotted against static lift/gross weight ratio for zero forward speed and 35 knots, and for the various ratios of horizontal propulsion thrust to total rotor lift ($T_{P_{max}}/T_{Z_{total}}$). The control forces for producing longitudinal acceleration are the thrust of horizontal propulsive units (T_{P_X}) and the X component of rotor thrust. Both of these parameters are independent of longitudinal rotor spacing, which is, therefore, not a parameter for this motion. The influence of forward speed is quite minor, as evidenced by the small separation of the graphs for zero and 35 knots. The 15-knot and 25-knot speeds would fall within this spacing, and for the sake of clarity are not plotted. Longitudinal acceleration has an inverse, but non-linear relationship to static-lift/gross weight ratio. This is to be expected, since the X component of rotor thrust is directly proportional to total rotor thrust ($T_{Z_{total}}$), which decreases toward zero as the static

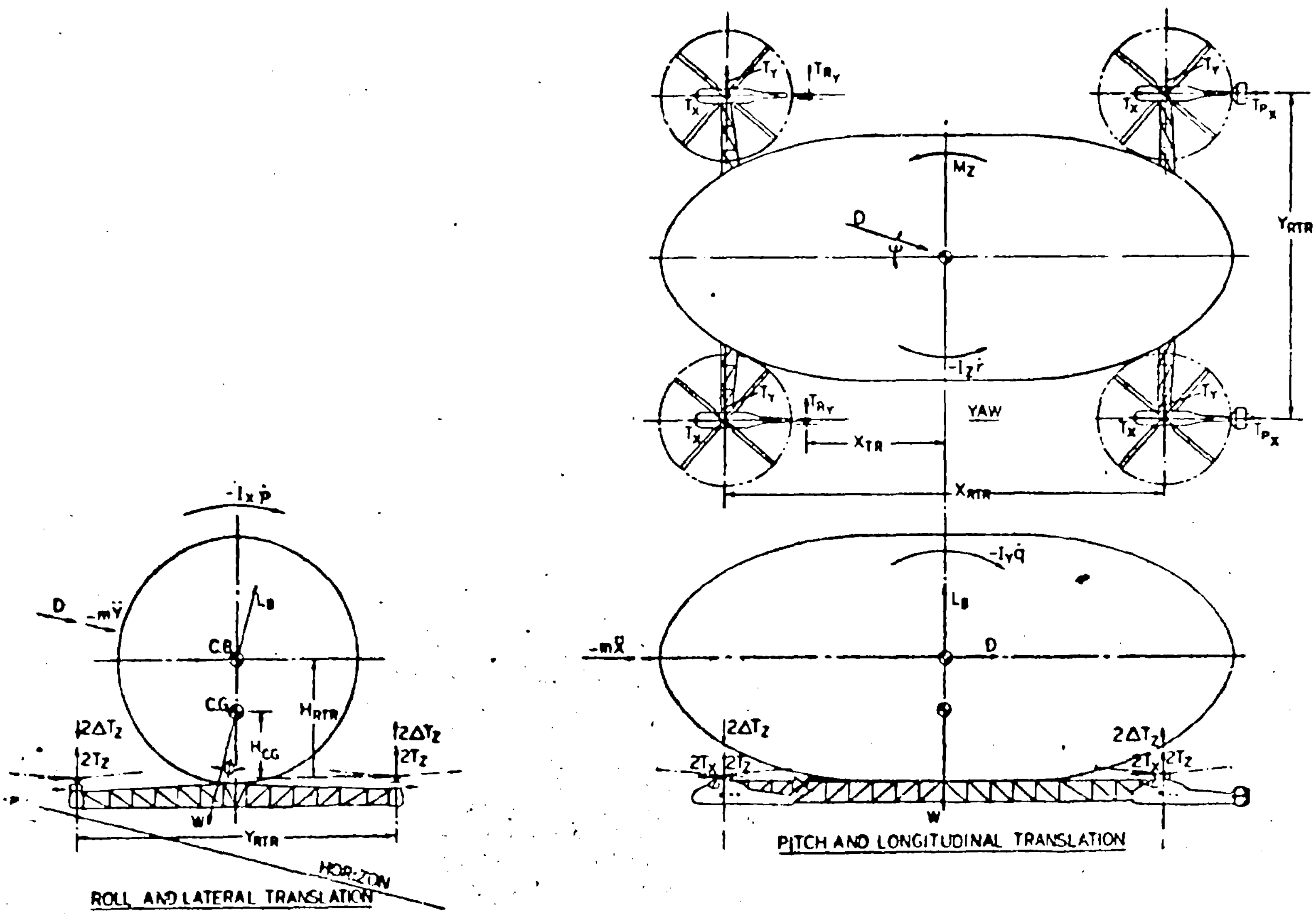


FIG. 4 FORCES AND MOMENTS ACTING ON HYBRID LTA VEHICLE (DWG. 97-C-0001)

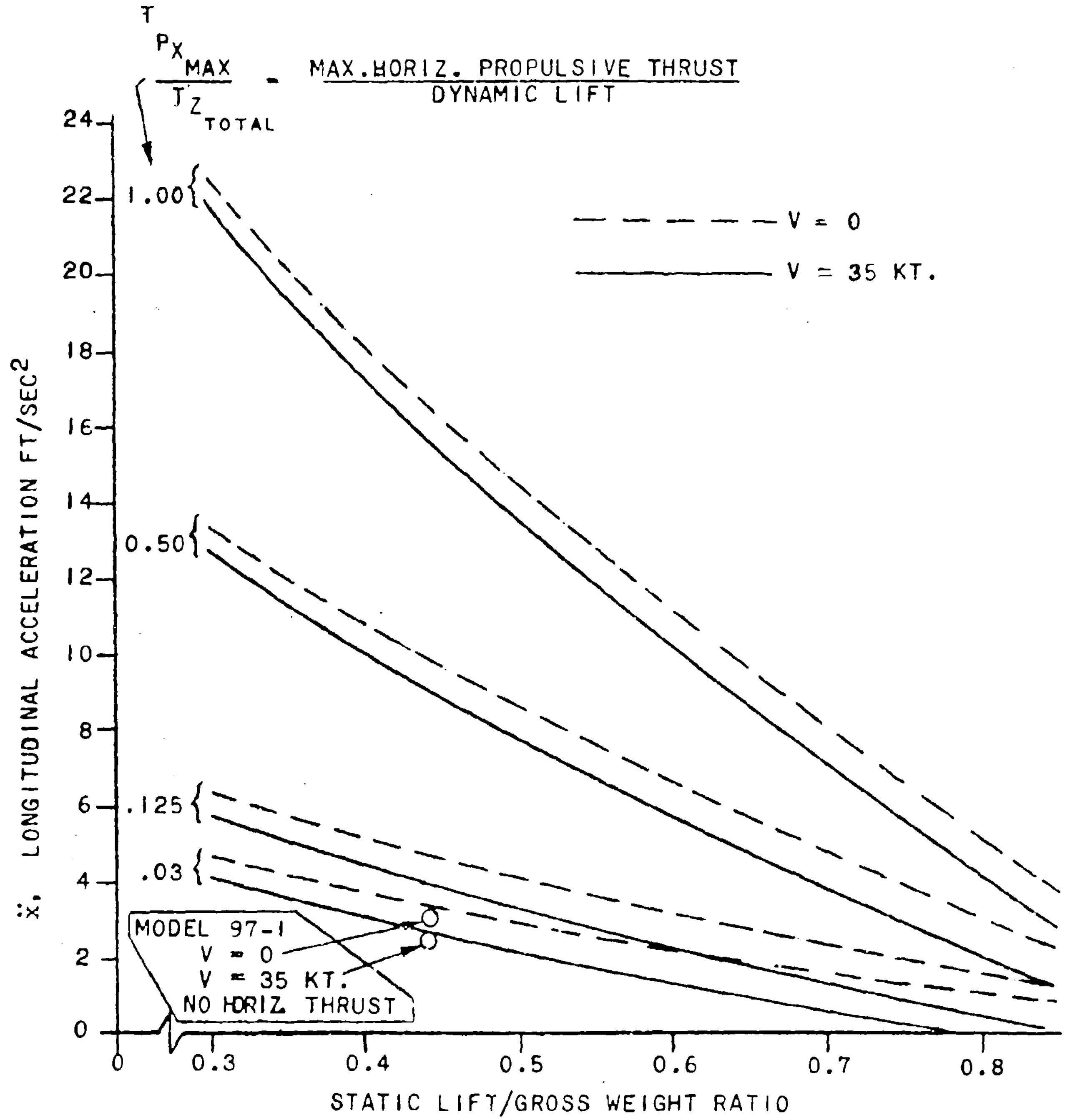


FIG. 5 LONGITUDINAL ACCELERATION CAPABILITY VS. STATIC LIFT/GROSS WEIGHT RATIO

lift/gross weight ratio increases toward 1.0. The amount of horizontal thrust available has a predictably important influence on longitudinal acceleration, although one should note that it has been varied over a very large range (from 3% to 100% of the dynamic lift). At high values of static lift/gross weight ratio the horizontal thrust is the primary means for producing longitudinal acceleration.

Two points are shown in Fig. 5, for zero and 35 knots, for Piasecki Model 97-1 (from Ref. 1), which had no horizontal thrust provisions. These points are quite consistent with the trends of the parametric curves falling slightly below the curves for 3% horizontal thrust.

Pitching Acceleration

Pitching control moments are produced by differential thrust variation between the forward and aft vertical thrust units (designated ΔT_Z). At forward speed, part of this moment is needed to counteract the nose-up moment of the thrust units, which in the configuration studied (see Fig. 4) are located substantially below the center of buoyancy and center of gravity.

Fig. 6 shows the strong inverse relationship between pitching acceleration capability and static lift/gross weight ratio for all speeds and all rotor spacing ratios considered. The reason for this is that the maximum amount of differential thrust at each vertical thrust unit was assumed to be a

constant 30% of the basic (average) thrust, a value representative of typical tandem helicopters. Thus for a static lift/gross weight ratio approaching 1.0, the dynamic thrust is relatively low, and so is the amount available for differential thrust. On the other hand, for a static lift/gross weight ratio approaching zero, the dynamic thrust is large, and so is the differential thrust.

Although Fig. 6 indicates that the pitching acceleration capability increases with increasing longitudinal rotor spacing, this effect is shown more clearly on Fig. 7 , where acceleration is plotted against rotor spacing.

The effect of longitudinal moment of inertia (I_Y) can be seen in Fig. 7 . For values of static lift/gross weight ratio approaching 1.0 (for example the 0.85 set of curves in Fig. 7) most of the effective pitching moment of inertia is due to the mass of the aerostat envelope, the internal gases, and the additional apparent mass of the surrounding air. Thus for this condition I_Y is essentially constant, independent of rotor spacing ratio. The curves are nearly straight lines. For lower values of static lift/gross weight ratio a greater part of the total I_Y is due to the mass of the thrust units, and I_Y increases with increasing rotor spacing. This, in turn, reduces the increase in acceleration which would otherwise result from the increased moment arms of the thrust units, and the curves are strongly curved concave

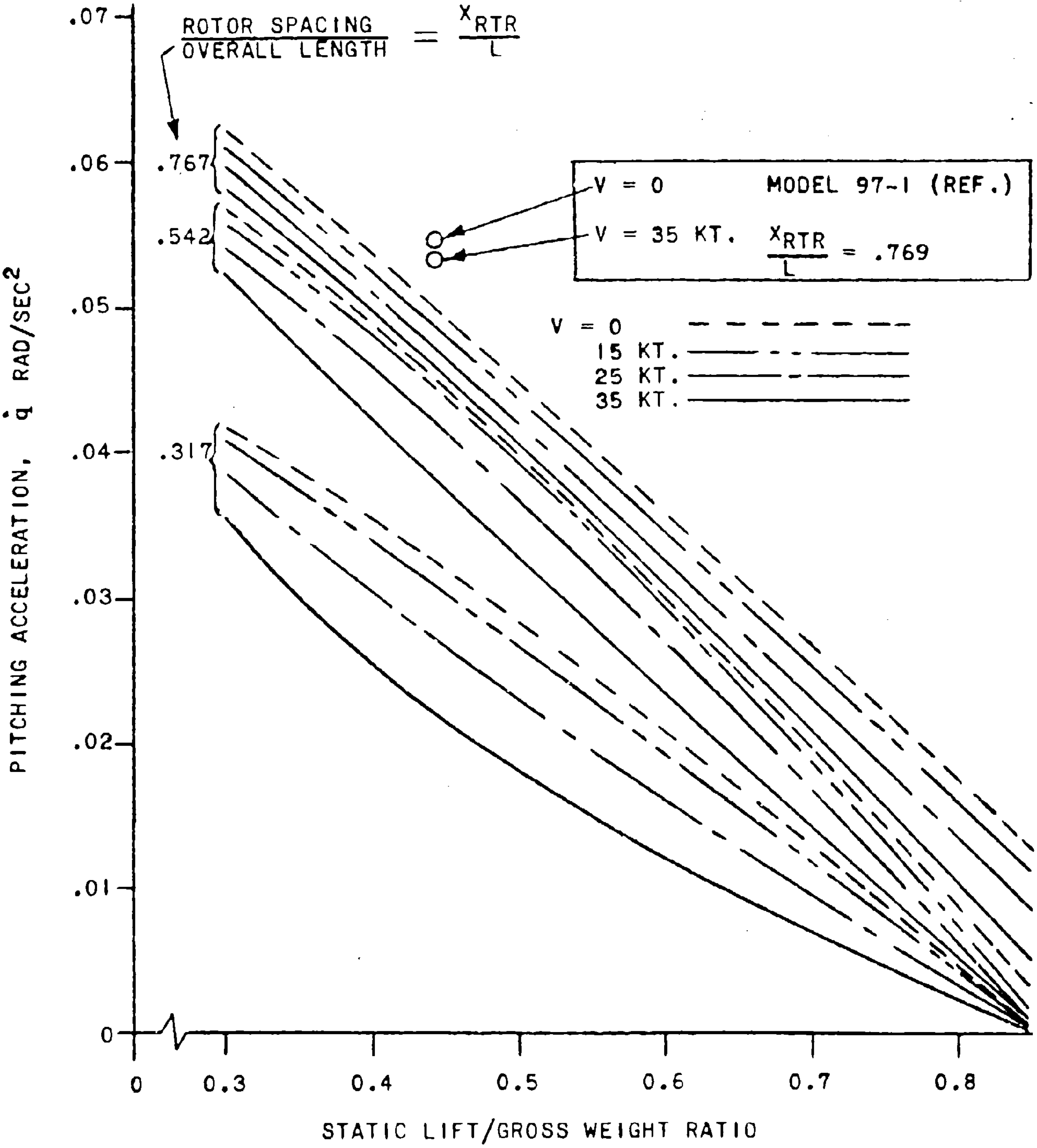


FIG. 6
PITCHING ACCELERATION CAPABILITY VS. STATIC LIFT/G.W. RATIO

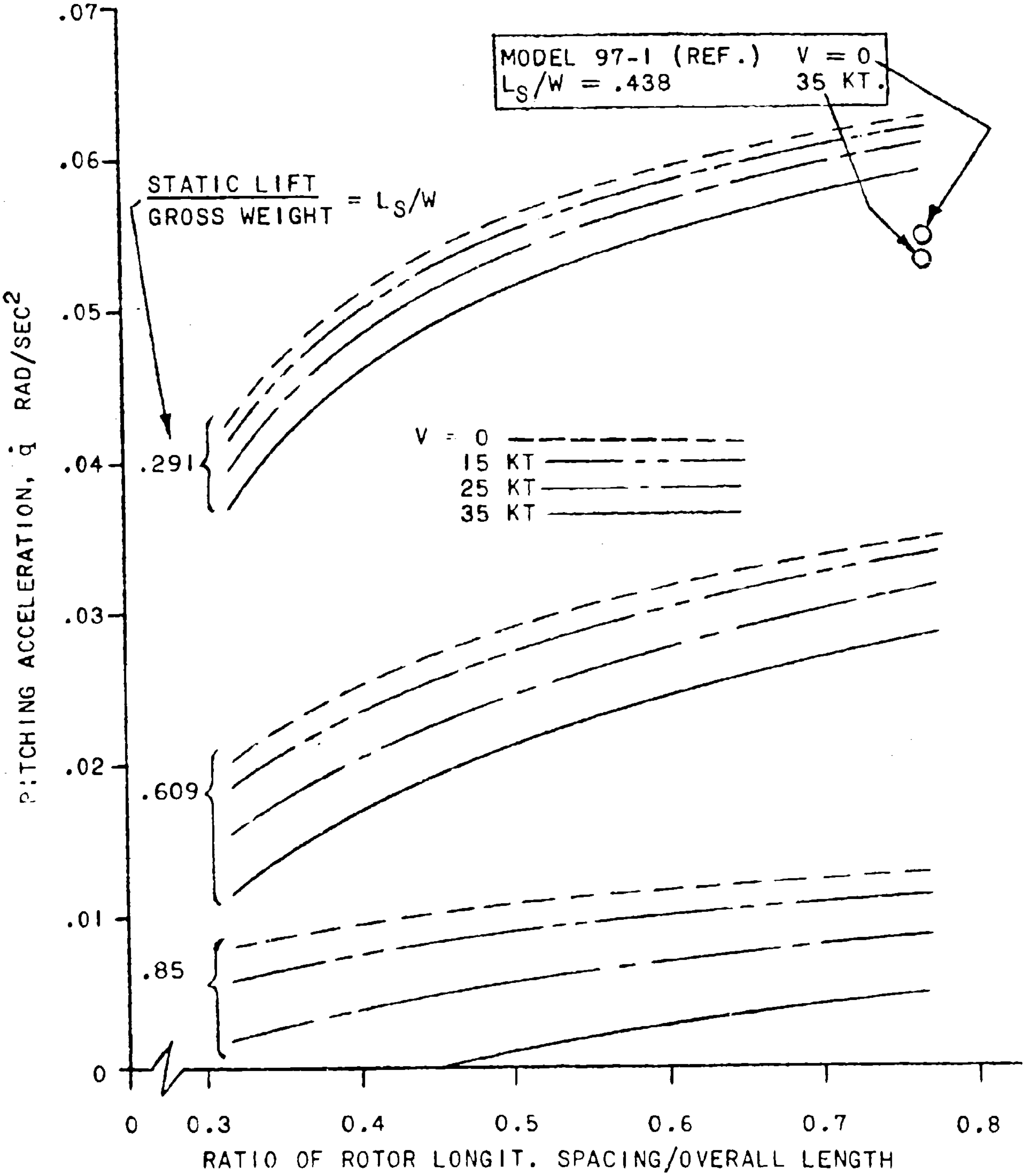


FIG. 7 PITCHING ACCELERATION CAPABILITY VS. RATIO OF ROTOR LONGIT. SPACING/OVERALL LENGTH

down.

Both Figs. 6 and 7 show that the pitching acceleration capability becomes smaller with increasing forward speed. The increased drag, acting approximately at the center of buoyancy, requires a larger amount of differential thrust for trim, because of the low position of the thrust units. Hence less differential thrust is available for acceleration. The effect of speed is accentuated at high static lift/gross weight ratios because the amount of differential thrust is smaller to begin with, and the amount required for trim is a larger percentage of the total.

Model 97-1, also plotted on Figs. 6 and 7, is seen to be consistent with the trend curves within about 10%. Its pitching acceleration capability is about 10% higher than the parametric point with the same rotor spacing ratio and static lift/gross weight ratio (best seen in Fig. 6). The probable reason is that this model, having a rigid aerostat, does not have ballonets at each end, with their mass of air which would add a significant contribution to moment of inertia in pitch. Thus, the Model 97-1 has a relatively smaller moment of inertia, and a correspondingly higher acceleration capability.

Lateral Acceleration

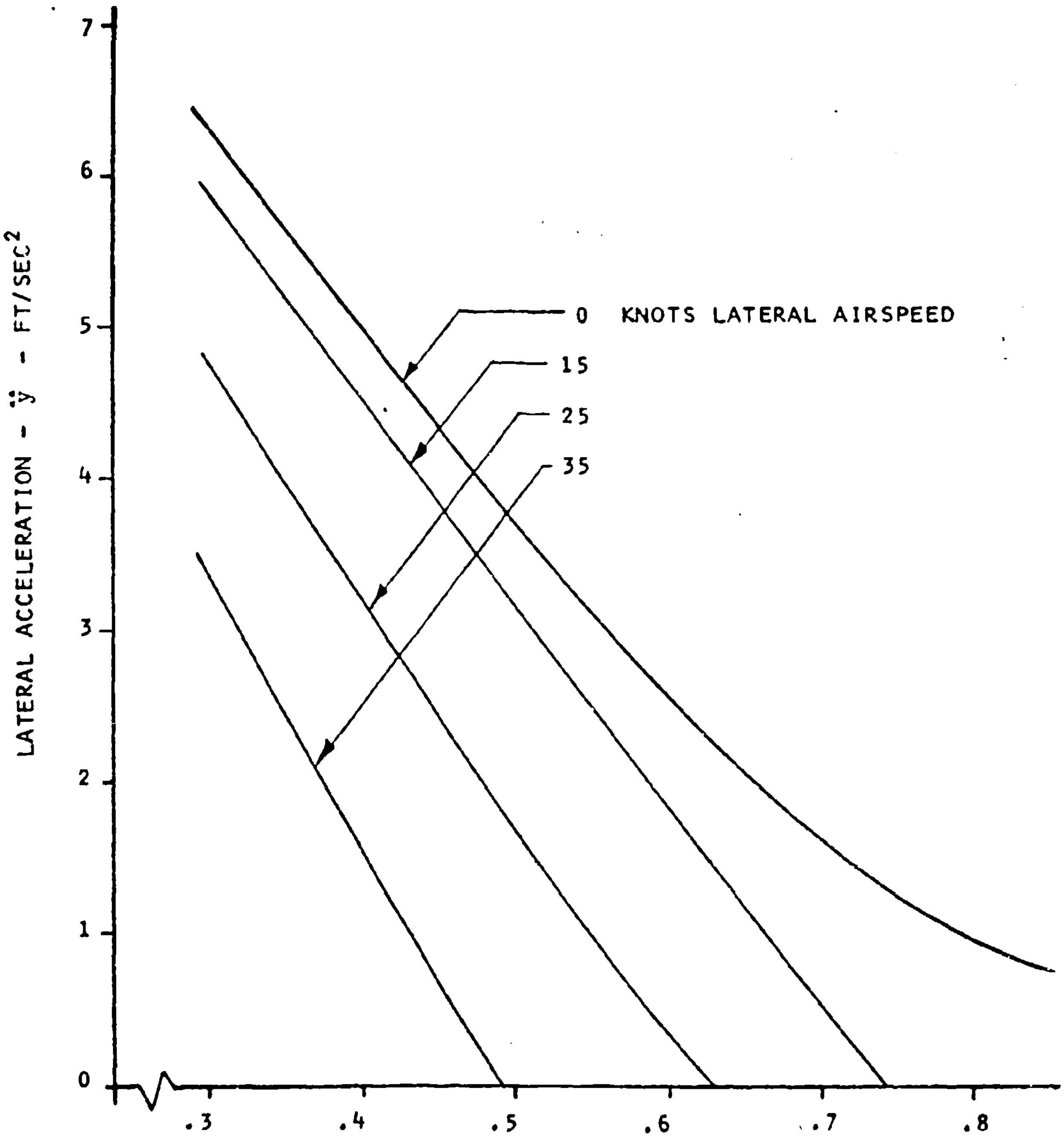
Lateral rotor spacing was not considered as a variable in this study. All of the matrix designs have the same clearance between rotors and aerostat hull, and consequently the lateral spacing on all is nearly the same, (see Fig. 3). Calculations for lateral controllability were based on the 76-ft. longitudinal spacing.

Fig. 8 shows lateral (or sideways) acceleration capability ($\ddot{y}$) plotted versus static-lift/gross-weight ratio for lateral velocities from zero to 35 knots. Lateral acceleration has a strong inverse relationship with static-lift/gross-weight ratio for the same reasons as does longitudinal acceleration, described earlier. Velocity, however, has a much greater influence on lateral than on longitudinal acceleration because of the much greater drag in the lateral direction (compare Figs. 8 and 5).

The effect of lateral velocity is shown more directly in Fig. 9, where lateral acceleration capability is plotted versus lateral airspeed. Model 97-1 is also shown on this figure, and is seen to display approximately the same trend as the matrix designs.

Roll Acceleration

Fig. 10 shows roll acceleration capability ($\dot{p}$) plotted versus static-lift/gross-weight ratio. Once again there is a strong inverse relationship because the rolling moment is



STATIC-LIFT/GROSS-WEIGHT RATIO

FIG. 8 LATERAL ACCELERATION CAPABILITY VS. STATIC-LIFT GROSS-WEIGHT RATIO

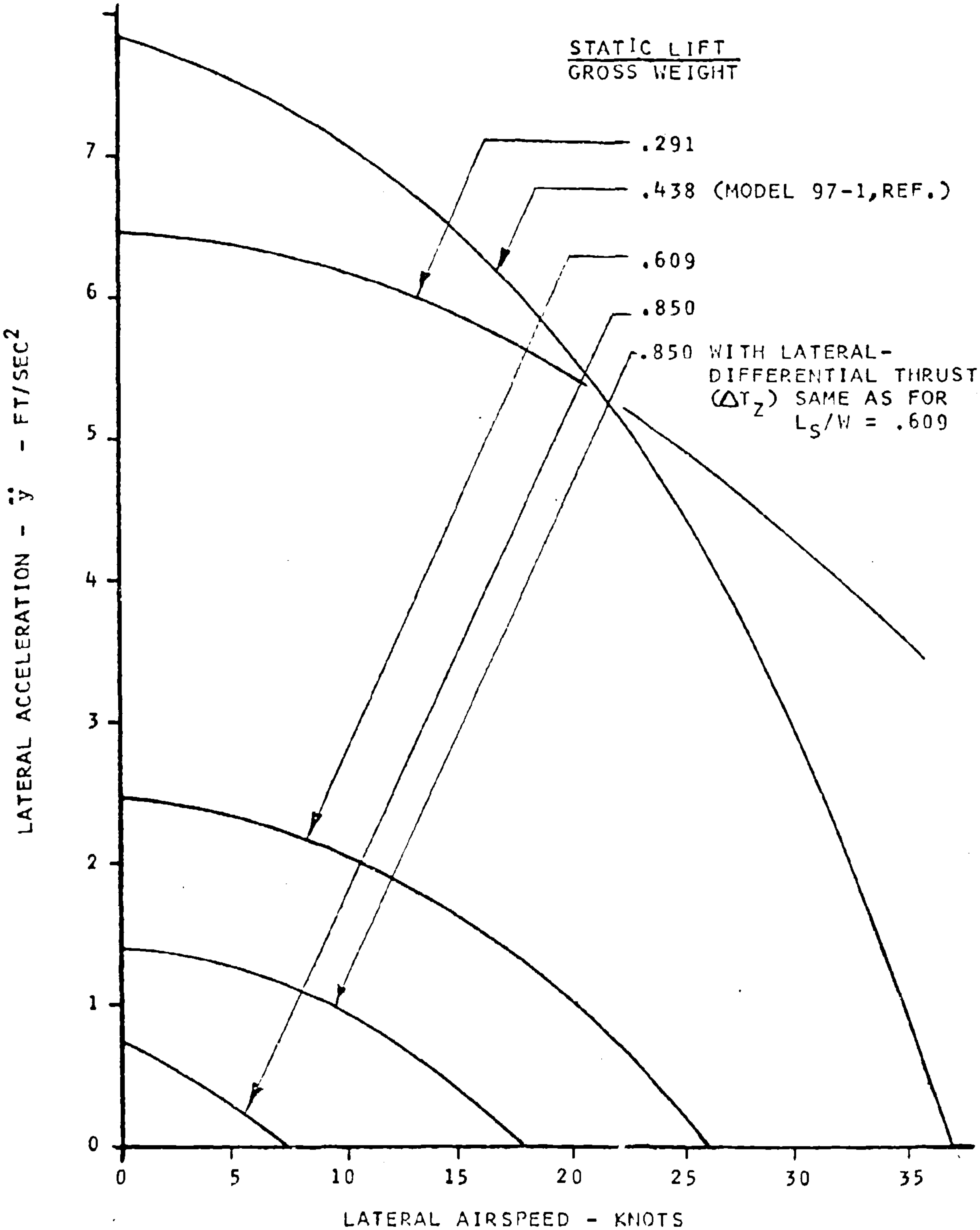


FIG. 9 LATERAL ACCELERATION CAPABILITY VS. AIRSPEED

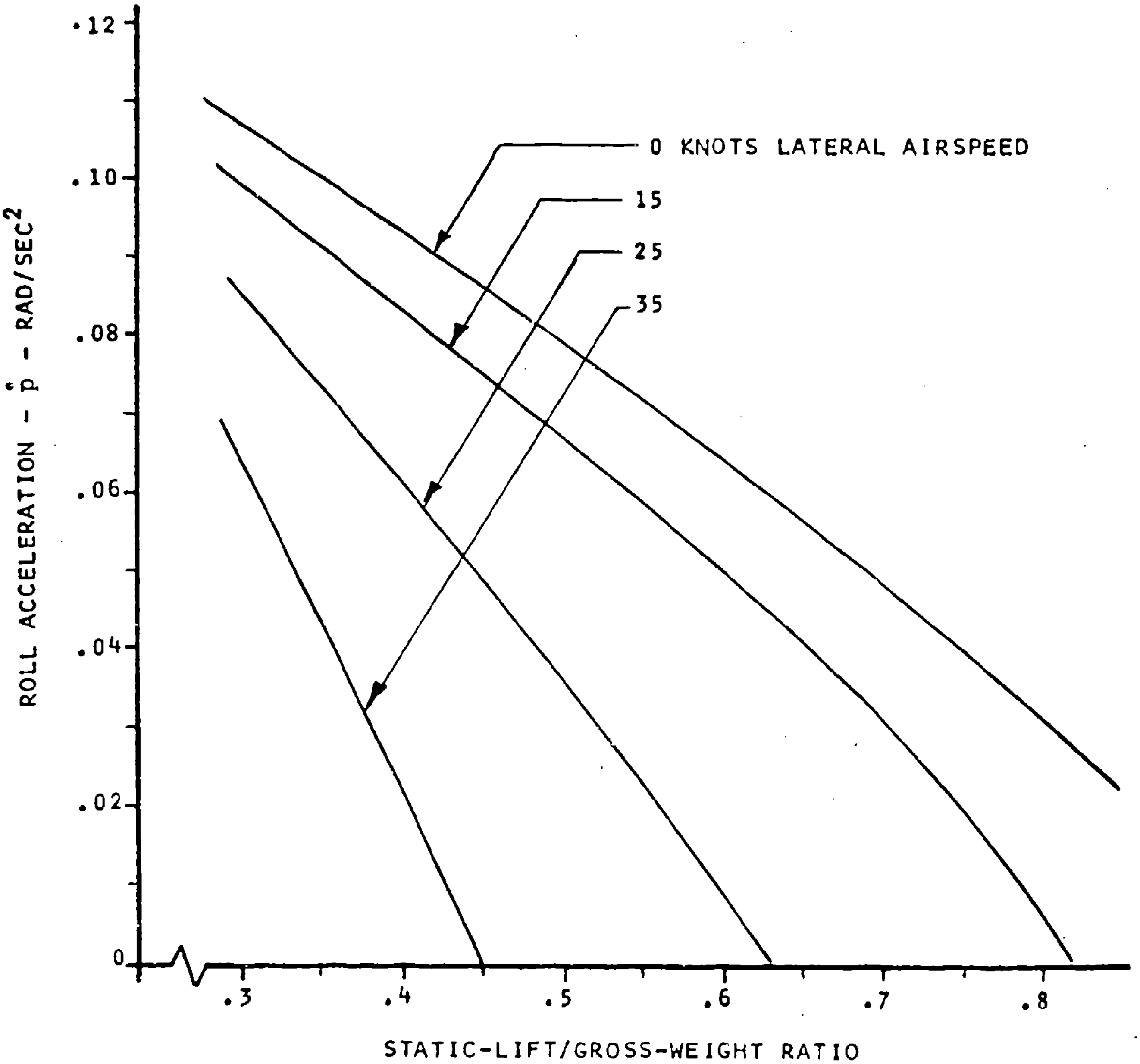


FIG. 10 ROLL ACCELERATION CAPABILITY VS. STATIC-LIFT GROSS-WEIGHT RATIO (β = 90°)

comprised of the lateral differential thrust, which is assumed at a constant 30% of the average thrust (see discussion of pitching acceleration). The roll acceleration capability is reduced with increasing velocity to a greater degree than is pitching acceleration, because the lateral drag is much higher. (Compare Figs. 10, 6 and 7).

Roll acceleration capability is plotted directly against lateral airspeed in Fig. 11. For each static-lift/gross-weight ratio there is a limiting lateral velocity where all available roll control moment is needed merely to trim the vehicle into a rolled attitude, so that none remains for acceleration to an increased roll attitude. This limiting velocity is seen to vary inversely with the static-lift/gross-weight ratio, Model 97-1 has been plotted on Fig. 11, and is seen to display the same general trend as the matrix vehicles.

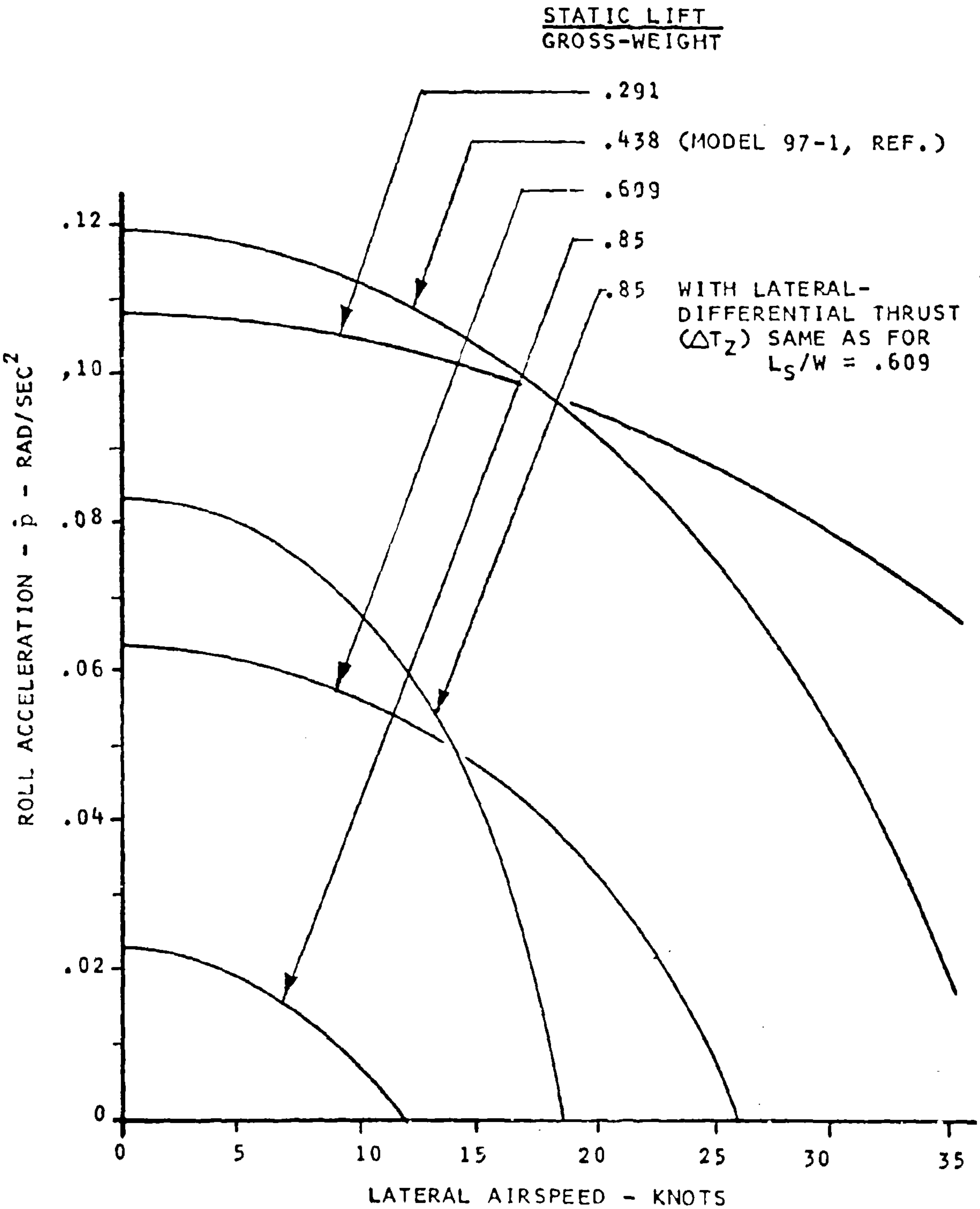


FIG. 11 ROLL ACCELERATION CAPABILITY VS. LATERAL AIRSPEED (β = 90°)

ACCELERATION IN YAW

The effect of five distinct parameters on yaw acceleration capability has been investigated. To show the separate effects of so many parameters on any single presentation become extremely confusing. Consequently, their effects are shown in five different ways, Figs. 12 through 16. On each of these figures variation in either three or four parameters are shown, while a typical constant value is maintained for the other(s).

Figs. 12 and 13 show that yaw acceleration capability decreases with increasing rotor spacing, except for high ratios of static-lift/gross weight. This was an unexpected result, since intuitively it seemed that a longer moment arm for the yaw-producing forces should produce a higher yaw acceleration. However, the weight of the thrust-producing units increases the yaw inertia of the vehicle sufficiently to more than offset the increased yaw moment. At a static-lift gross weight ratio of .85, the weight of the thrust-producing units relative to the aerostat is sufficiently small that the additional moment of inertia from increased spacing is balanced by the additional moment arm, and the acceleration is essentially independent of spacing.

Speed in itself does not have much influence, particularly at zero sideslip angle, as seen by the small change between zero and 35 knots (Fig. 12). In combination with high angles of sideslip, however, speed becomes significant, as can be seen in Fig. 14.

Fig. 12 also shows that the static-lift/gross-weight ratio is a highly significant parameter. The vehicle with the smallest percentage of static lift is the most maneuverable. This relationship is shown more clearly in Figs. 14 and 15, where yaw-acceleration capability is plotted directly against static-lift/gross weight ratio.

Use of auxiliary thrust in the horizontal plane is a powerful method of providing yaw moment. In the present study horizontal thrust of varying magnitude was assumed to act in a fore-and-aft direction at a location behind each of the aft main lifting rotors (see Fig. 4). The magnitude of the maximum available horizontal thrust is expressed as a fraction of the rotor lift. Acting together, the horizontal thrusters produce forward (or aft) propulsion, but acting differentially they produce a yawing moment. Their effectiveness is clearly shown in Figs. 13 and 15.

As expected, the yaw acceleration capability at airspeeds other than zero is dependent upon the sideslip angle since the wind then produces its own yawing moment. This dependency on sideslip is shown in Fig. 16 for a wind speed of 25 knots. The aerodynamic moment produced by the wind is greatest at 45 degrees; hence the acceleration capability is smallest at that azimuth. Also, Fig. 16 again points out that the acceleration capability is higher with a smaller rotor spacing.

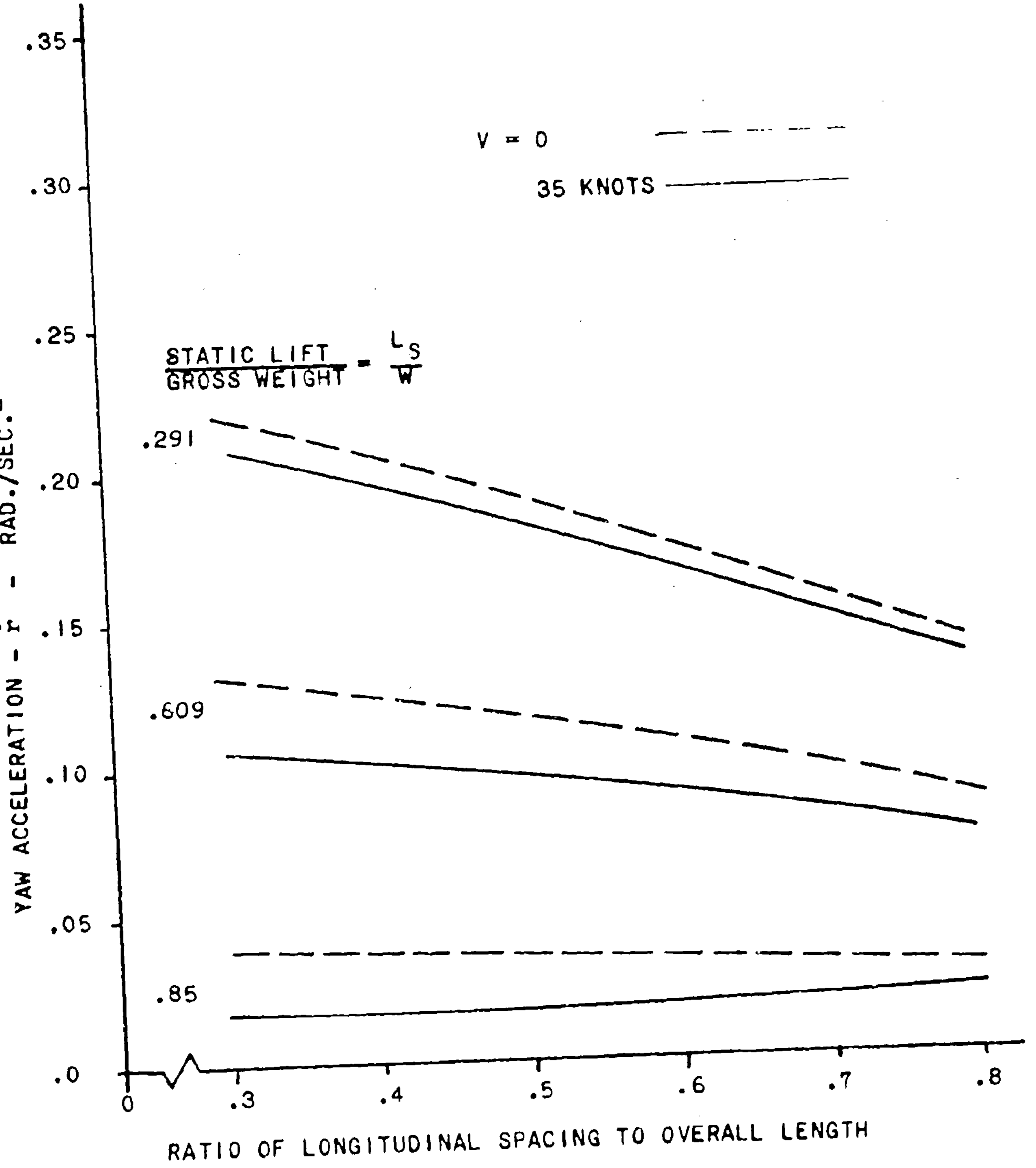


FIG. 12 YAW ACCELERATION CAPABILITY VS. ROTOR SPACING RATIO (MAX. HORIZ. PROPULSIVE THRUST/DYNAMIC LIFT RATIO = .125; SIDESLIP ANGLE = 0°)

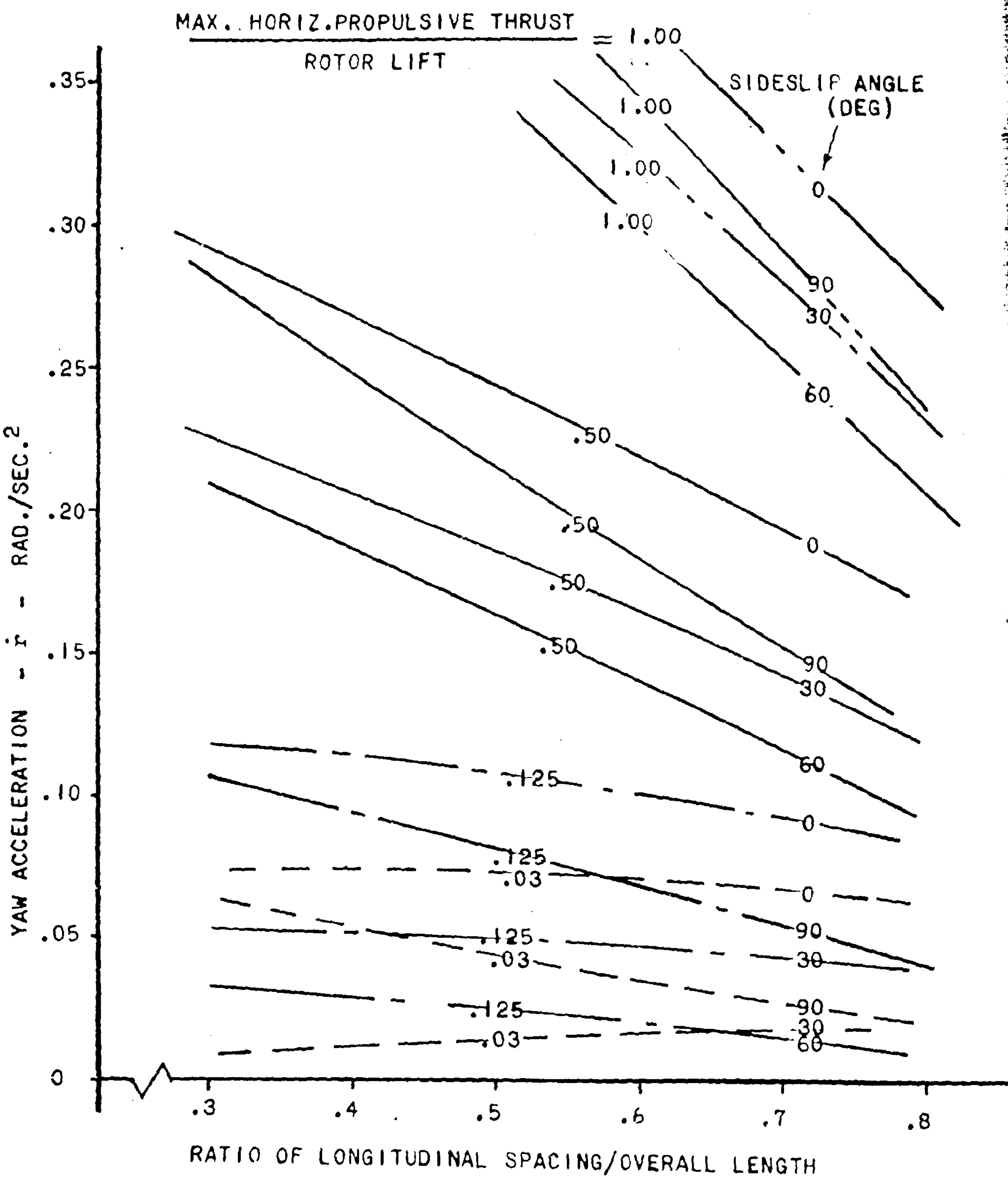


FIG. 13 YAW ACCELERATION CAPABILITY VS. RATIO OF ROTOR LONGITUDINAL SPACING/OVERALL LENGTH. (V = 25 KNOTS; STATIC-LIFT/GROSS WEIGHT RATIO = .609)

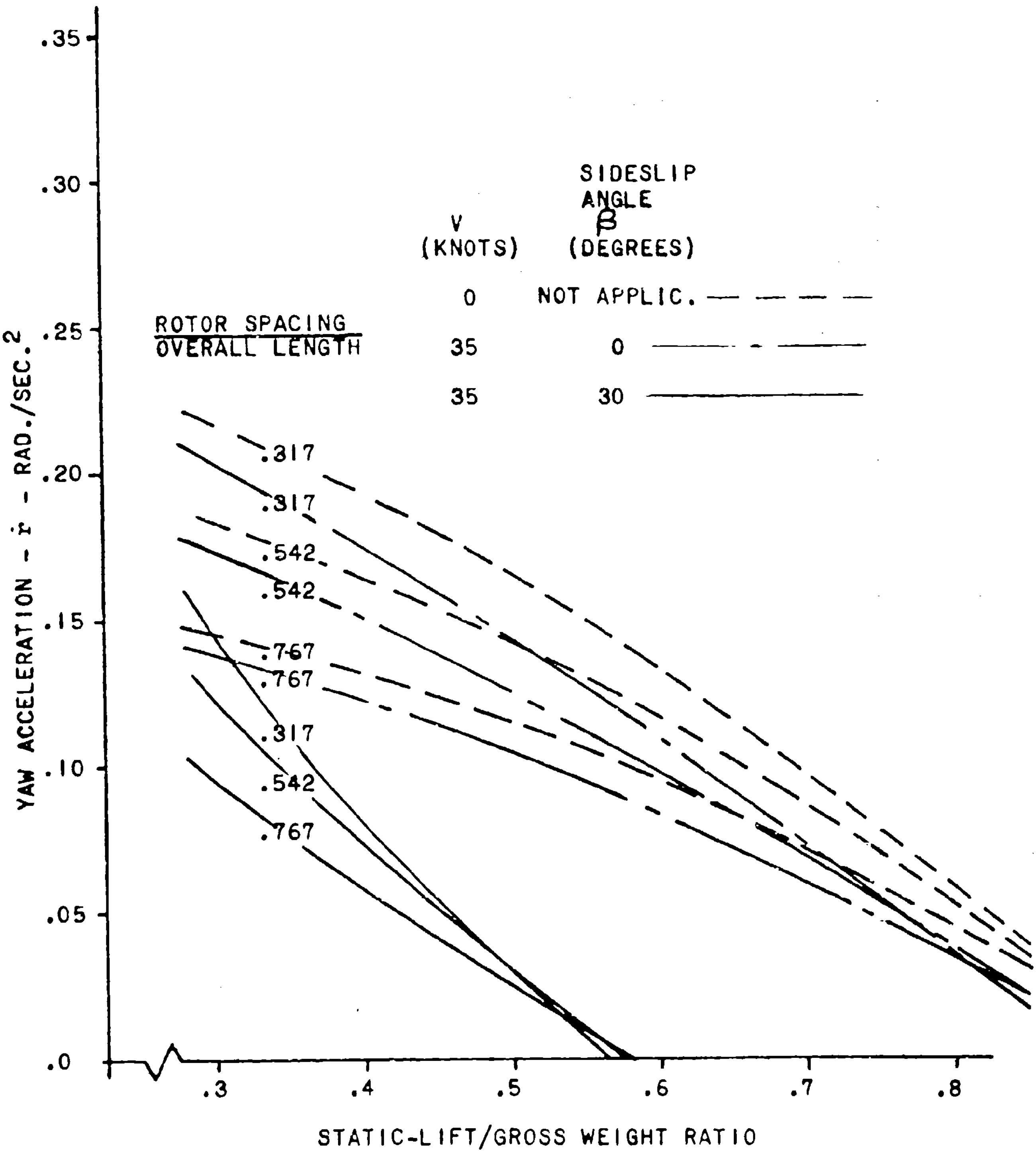


FIG. 14 YAW ACCELERATION CAPABILITY VS. STATIC-LIFT/GROSS WEIGHT RATIO. (MAX. HORIZ. PROPULSIVE THRUST/ROTOR LIFT RATIO = 0.125)

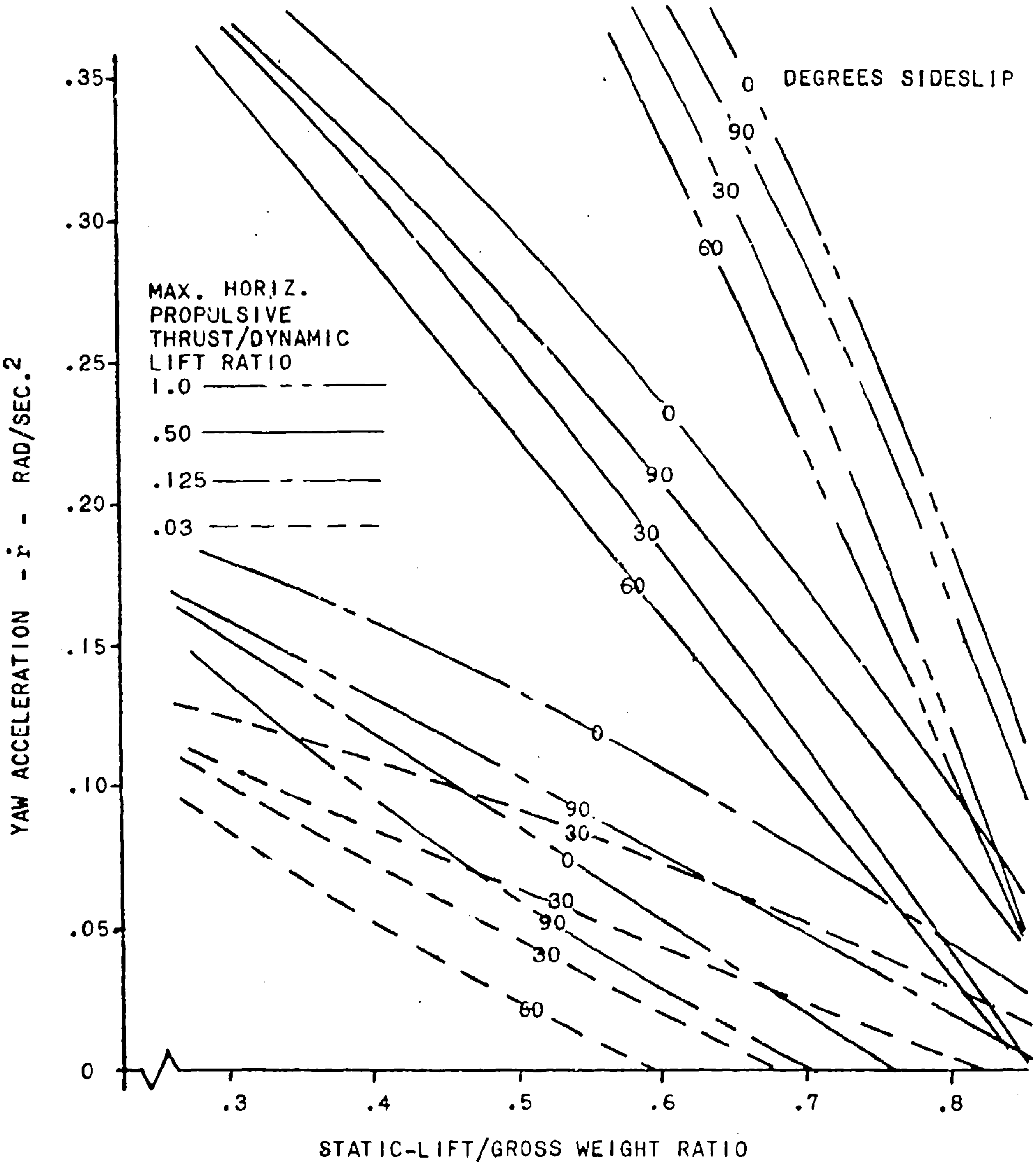


FIG. 15 YAW ACCELERATION CAPABILITY VS. STATIC-LIFT/GROSS WEIGHT RATIO. (ROTOR SPACING/OVERALL LENGTH RATIO = .542: V = 25 KNOTS)

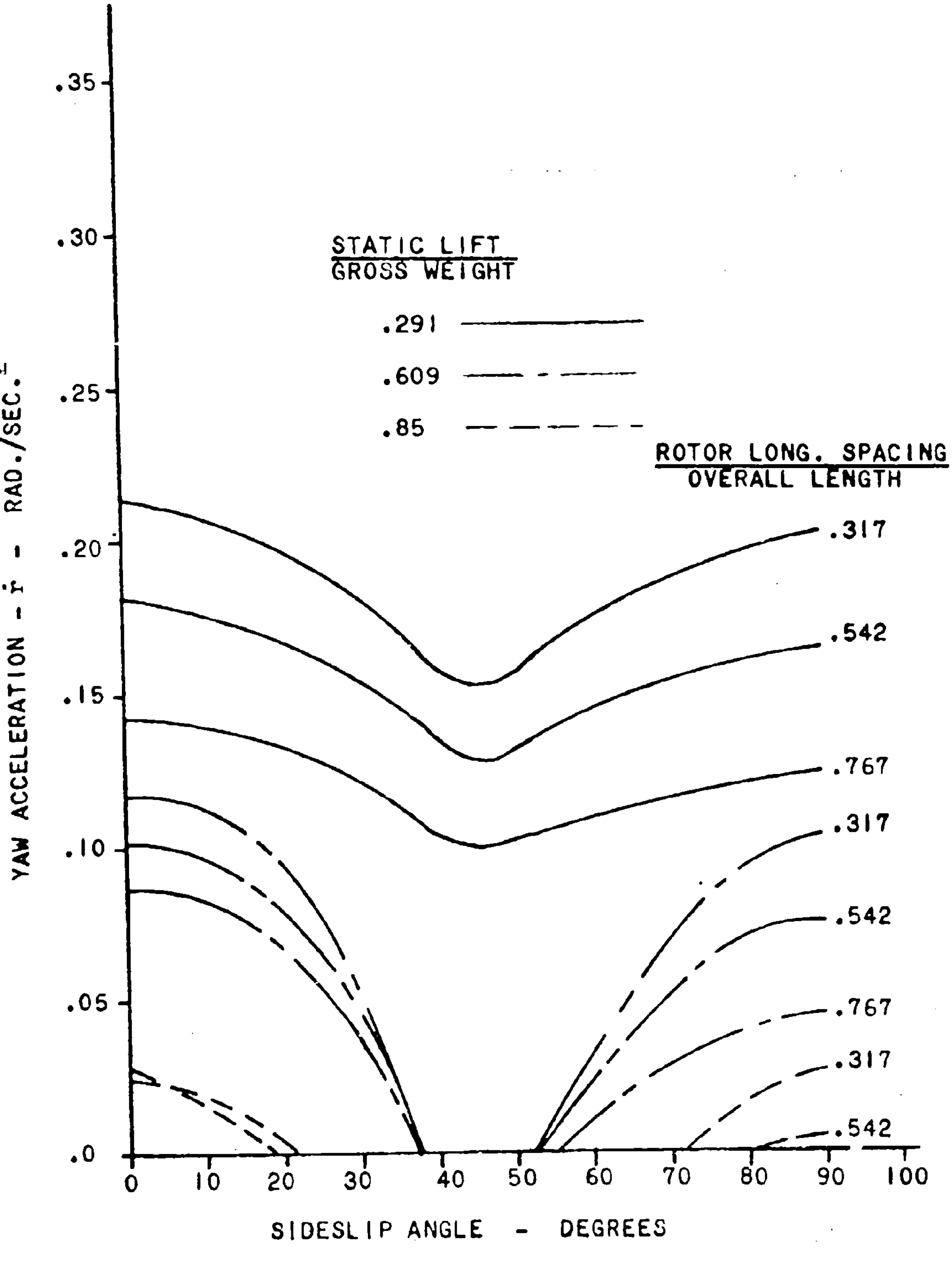


FIG. 16 YAW ACCELERATION CAPABILITY VS. YAW ANGLE. (V = 25 KNOTS; MAX. HORIZ. PROPULSIVE THRUST/DYNAMIC LIFT RATIO = .125)

Comparison with Heli-Stat Model 97-1

The Piasecki Heli-Stat Model 97-1, described and analyzed in Ref. 1, had geometric and dynamic characteristics as shown in Fig. 2 , From interpolation of results from the matrix point designs to correspond with the ratios of static-lift to gross weight, and of rotor longitudinal spacing to overall length, the comparison table, Fig. 17 , is obtained.

The correlation between Model 97-1 and the matrix points is seen to be within 12% for speeds of zero and 25 knots and for all axes except lateral translation and roll. The lower degree of correlation in these two axes is the result of a somewhat different lateral control configuration. As shown in Fig. 4 , lateral forces are produced in the matrix designs by lateral thrusters (tail rotors) on the two forward main thrust units, as well as by lateral components of the main rotor thrusts. The two aft thrust units are equipped with horizontal thrusters for longitudinal thrust only. Model 97-1, on the other hand, had lateral thrusters on all four main thrust units and, therefore, twice as much lateral thrust from this source. It is this feature which gives Model 97-1 a higher lateral acceleration capability. Moreover, Model 97-1 can be trimmed for a given lateral airspeed at a smaller roll angle because it was designed with greater lateral thrust than the matrix designs. Hence a larger proportion of roll control is available for roll acceleration

FIG. 17 CONTROLLABILITY COMPARISON BETWEEN MODEL 97-1 HELI-STAT AND INTERPOLATIONS FROM MATRIX POINT DESIGNS

		V = 0			V = 25 KNOTS		
CONTROL AXIS	ACCELERATION UNITS	97-1	DESIGN MATRIX	97-1 / DESIGN MATRIX	97-1	DESIGN MATRIX	97-1 / DESIGN MATRIX
LONGITUDINAL TRANSLATION	FT/SEC^2	2.88	3.16	1.08	2.64	2.55	.97
PITCH	RAD/SEC^2	.0546	.0525	.96	.0538	.0475	.88
LATERAL TRANSLATION	FT/SEC^2	7.85	4.45	.63	4.35	2.62	.60
ROLL	RAD/SEC^2	.1203	.0885	.74	.0741	.052	.70
YAW	RAD/SEC^2	.0898	.0825	.92	.0866	.0775	.89

Application to Real Designs

The parametric analyses conducted for this report were based on a grid, or matrix, of point designs having three fixed values for static-lift/gross weight ratio. In any real design this quantity is a variable, dependent upon the vehicle's empty weight and the amount of useful load being carried. However, from these parametric results the behavior of such a real design can be estimated.

To illustrate a typical real-design application, Model C-76/.609 has been selected. The .609 ratio of static lift to gross weight has been taken to represent the fully loaded condition, for which estimated weight breakdowns can be found in the Appendix. When off-loaded approximately 50%, this design is found to have a ratio of static-lift to gross weight of 0.85, another of the fixed values used in the matrix study. However, since it is now considered to be a fixed design, operating at part load rather than full load, the control available for pitch, roll, and yaw (differential thrust and auxiliary horizontal thrust) will remain the same as they were in the fully loaded condition, as opposed to the smaller values found in the .85 ratio matrix points.

The .85-static-lift/gross weight ratio designs were, therefore, re-analyzed using the values for differential thrust and auxiliary thrust from the .609-ratio designs. Results are shown as follows:

Longitudinal Translation is shown on Fig.18 plotted against airspeed, for an horizontal thrust ratio of .125, one of the constant ratios used in the matrix (solid line), and a ratio of .455, which represents the same value of horizontal thrust, in pounds, as the corresponding matrix point with .609 static-lift gross-weight ratio (dotted line). The dotted line can be considered to show the .609-ratio matrix designs when operating with approximately 50% design payloads.

Pitch is shown on Fig. 19 plotted against longitudinal spacing ratio for speeds of zero and 35 knots. The solid curves ($\Delta T_{X_{max}}/T_Z = .30$) are identical to those in Fig. 7 . The dotted curves ($\Delta T_{Z_{max}}/T_Z$) once again are representative of the .609-ratio matrix designs operating with approximately 50% design payload.

Lateral Translation and Roll are shown plotted against airspeed on previous Figs. 9 and 11 . On each, along with the regular matrix designs is shown a curve for the .85 static-lift ratio, but with lateral differential thrust taken from the .609 ratio.

Yaw is shown on Fig. 20 plotted against sideslip angle at a speed of 15 knots. As in Fig. 18 the solid curves are for an auxiliary thrust ratio of .125, while the dotted curves are for a ratio of .455.

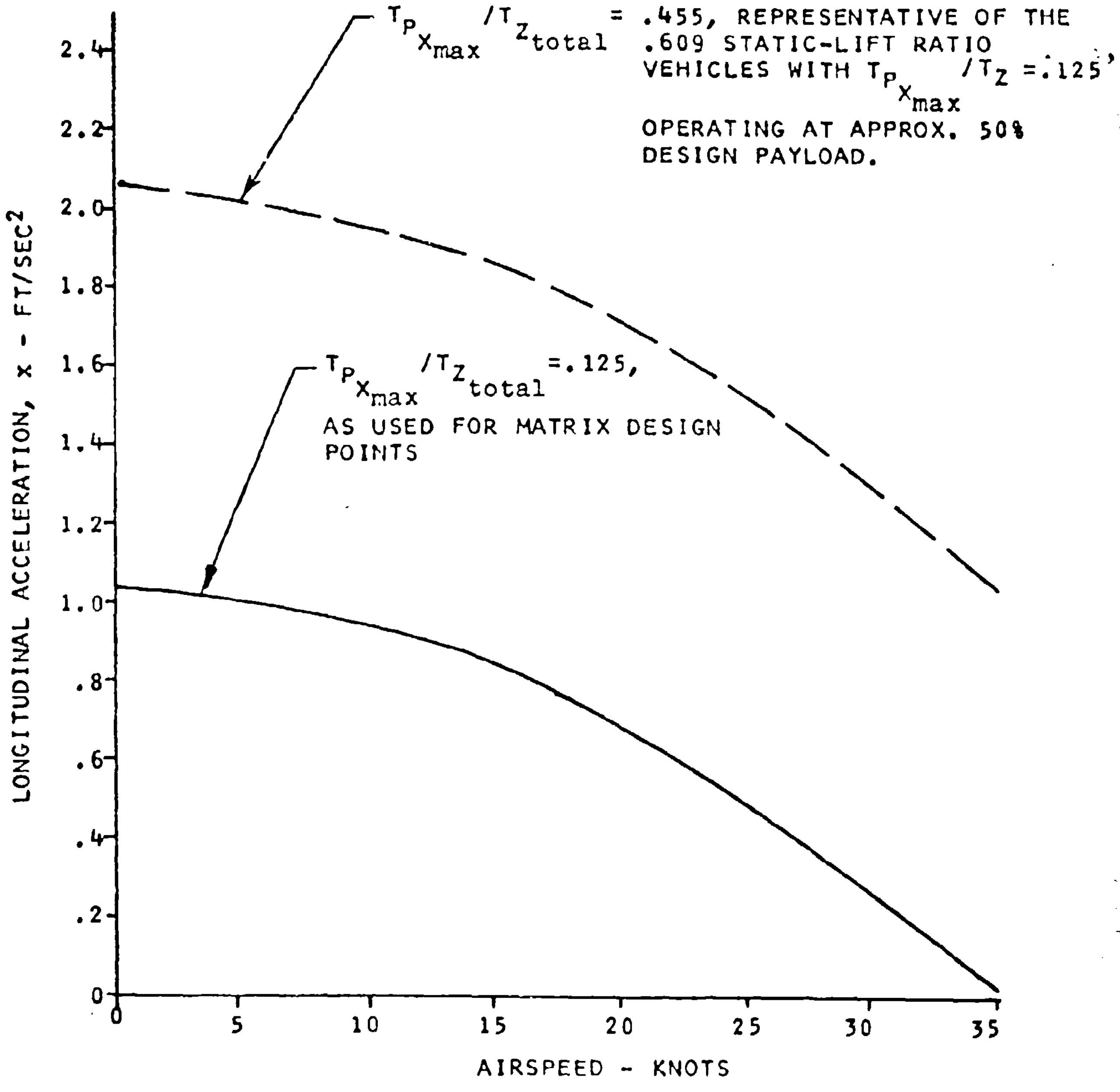


FIG. 18 LONGITUDINAL ACCELERATION CAPABILITY VS. AIRSPEED, AS AFFECTED BY AVAILABLE HORIZONTAL PROPULSIVE THRUST/DYNAMIC LIFT RATIO ($T_{P_{X_{max}}}/T_{Z_{total}}$).

STATIC LIFT/GROSS WEIGHT RATIO = .85

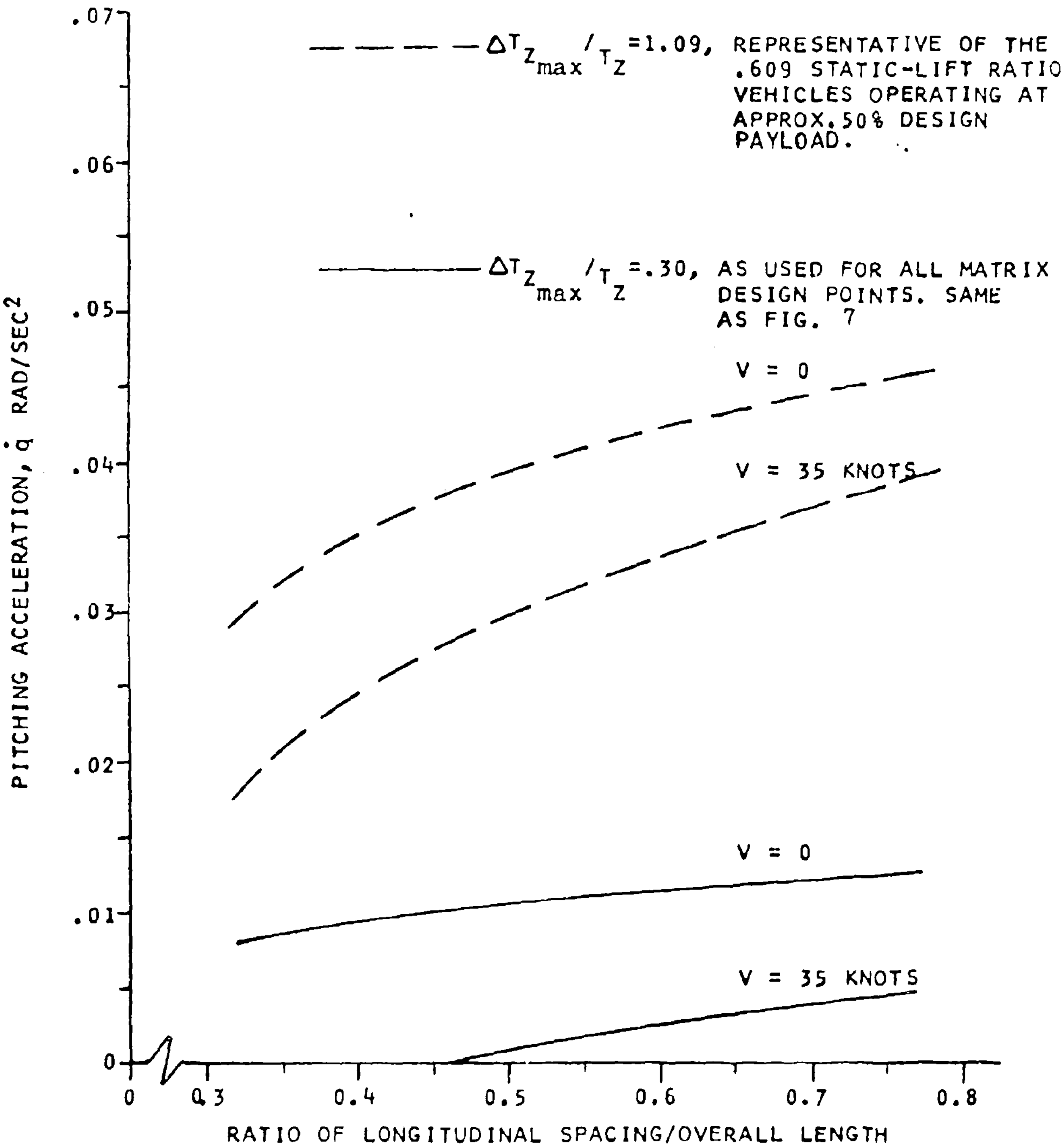


FIG. 19 PITCHING ACCELERATION CAPABILITY VS. RATIO OF LONGITUDINAL SPACING/OVERALL LENGTH, AS AFFECTED BY AVAILABLE DIFFERENTIAL THRUST (ΔT_Z). STATIC-LIFT/GROSS WEIGHT RATIO=.85

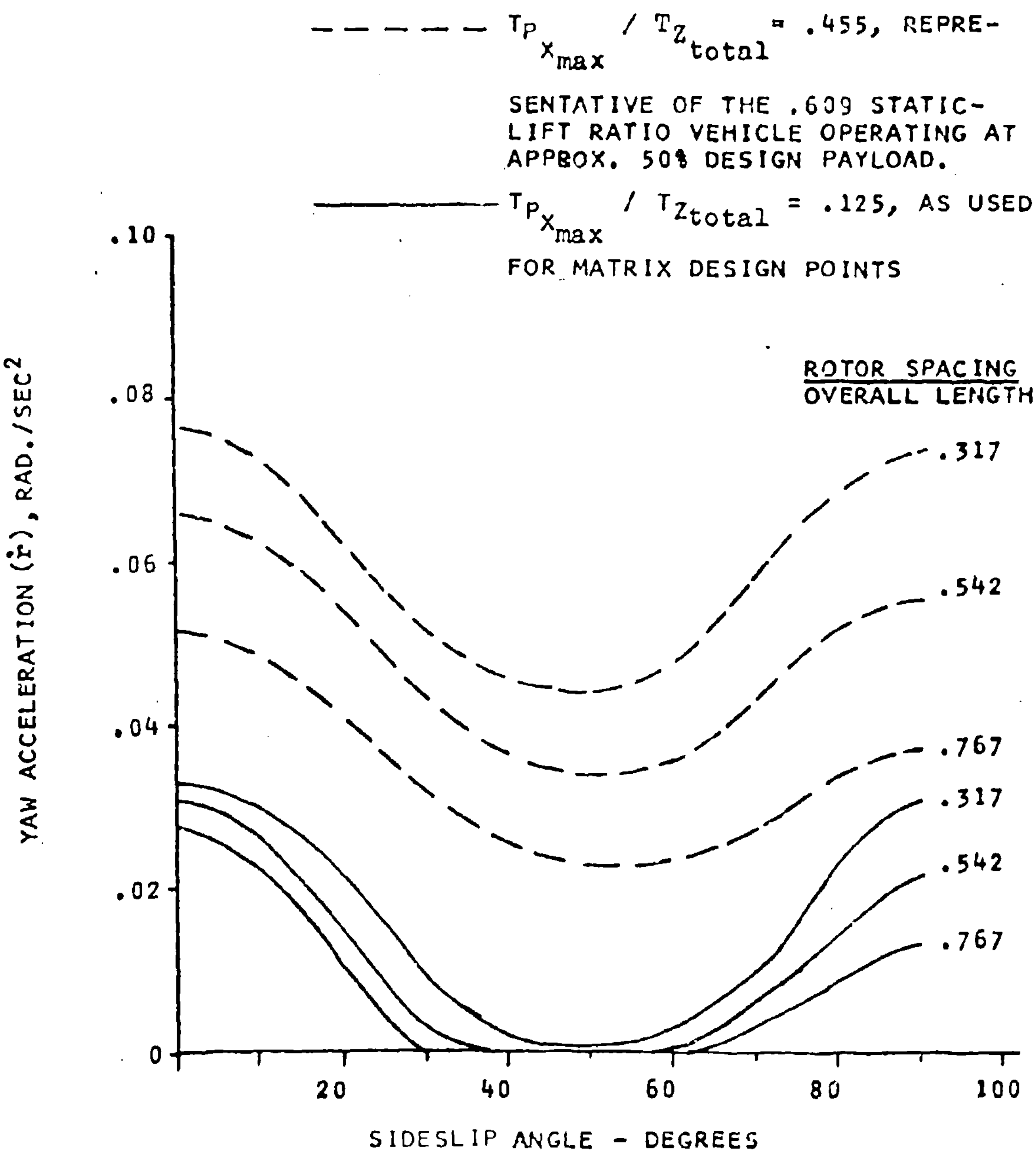


FIG. 20 YAW ACCELERATION CAPABILITY VS. SIDESLIP ANGLE, AS AFFECTED BY AVAILABLE HORIZONTAL PROPULSIVE THRUST/DYNAMIC LIFT RATIO ($T_{P_{X_{max}}} / T_{Z_{total}}$). STATIC LIFT/GROSS WT. RATIO = .85; V = 15 KNOTS

Final graphs of controllability vs. loading condition are shown on Fig. 21. These graphs were constructed using points for 100% and 50% payload as described in the preceding paragraphs. They were then extrapolated down to zero payload.

For zero airspeed, pitch and roll controllability decrease with increasing payload, since the available control moments (from differential thrust) remain constant, while moments of inertia are increased. (Even though the payload was considered as essentially a point mass, its location well below the vehicle center of mass gave it a significant contribution to pitch and roll, but not yaw moments of inertia). However, longitudinal and lateral translation and yaw controllability all decrease with decreasing payload. Main rotor thrust vector components play a large part in these particular modes. Since these thrust components are a direct function of dynamic lift, they become smaller with decreased payload.

At 15-knots airspeed longitudinal translation, pitch, and yaw acceleration are not greatly different from their zero-speed values. Lateral translation is substantially reduced, and the slope of the graph for roll is reversed. A reduction in lateral translation capability is accompanied by increased roll control and roll angle to maintain lateral force trim. Thus less roll control is available for roll acceleration.

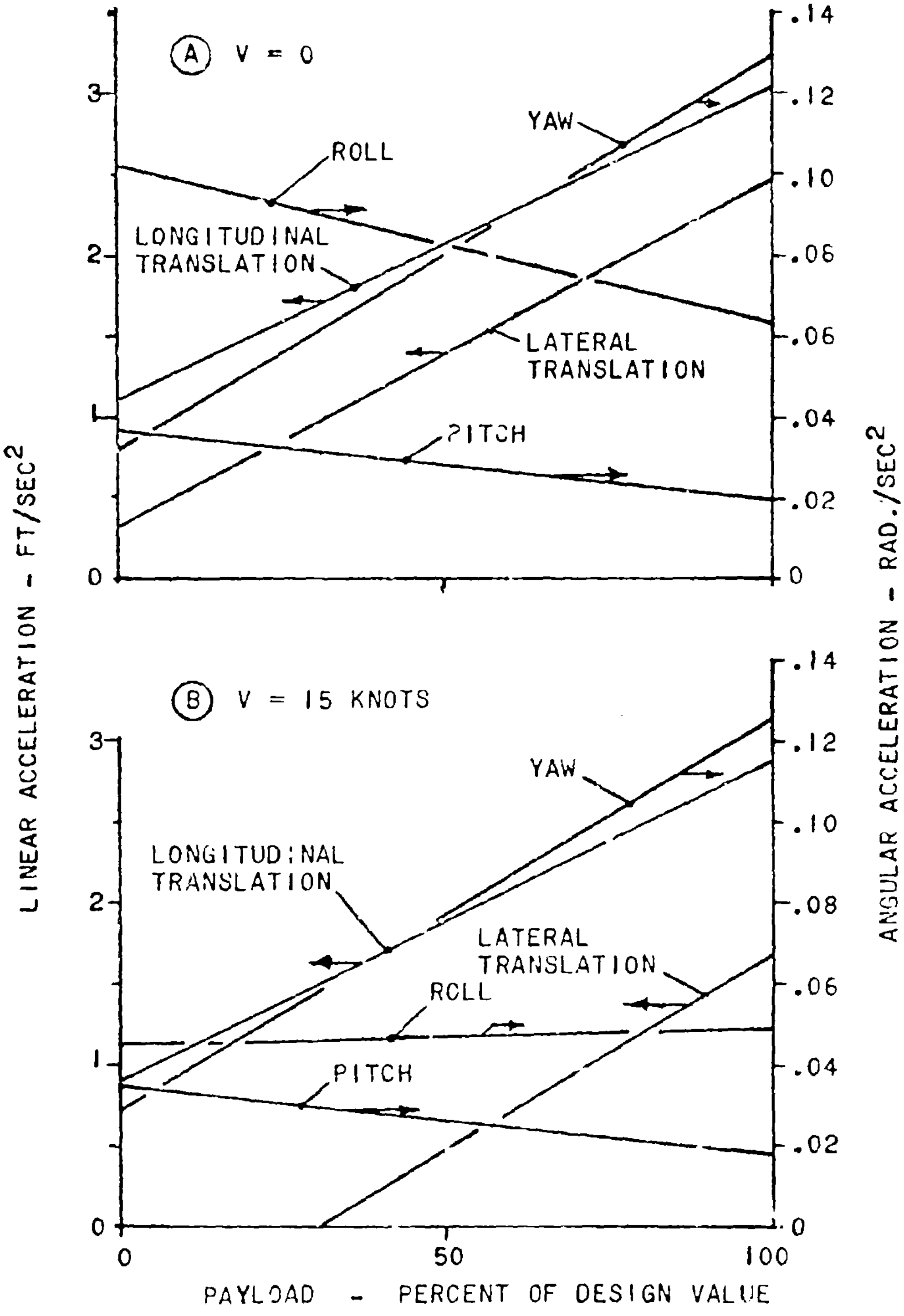


FIG. 21 CONTROLLABILITY VARIATION WITH LOADING CONDITION: MODEL C-76/.609

In a light condition (payload ratio less than .35), the maximum sideward airspeed for lateral trim is about 15 knots. However, hovering flight in a 90-degree crosswind will normally not be required. For those applications when it would be required, provision would have to be made for ample lateral thrust under conditions of light loading.

Thus the parametric results developed herein can be used to determine the control response of a "real" preliminary design vehicle. The example just described represents a design which the fully loaded condition, happens to fit one of the matrix points and in the 50%-loaded condition to nearly fit another matrix point. Hence Figs. 18, 19, and 20 could be constructed directly from calculated values, without the need for interpolation. However, other designs falling within the matrix limits can be analyzed in similar fashion. Although all possible combinations of parameters have not been plotted in the figures in this report, the calculated results can all be found in the Appendix. Data for designs with parameters within the matrix limits but not equal to any of the specific matrix points can be easily interpolated, using the nearest appropriate points.

Comparison With Specification MIL-H-8501A

Specifications or standards have not been promulgated for controllability requirements of a lighter-than-air vehicle (hybrid or not). As a matter of interest, however, Model C-76/.609 has been evaluated in pitch, roll, and yaw, in terms of paragraphs 3.2.13, 3.3.18, and 3.3.5, respectively, of Spec. MIL-H-8501A, Amendment 1 (Ref. 4). This specification, of course, when written was dealing with a vehicle of the order of one-tenth or less of the size of an anticipated LTA vehicle. However, the effect of size on controllability requirement was considered to some degree, in that the formulas for controllability permit slower motions for increased size of helicopter. The calculated values shown in Fig. 22 for the Heli-Stat Model C-76/.609 are several orders of magnitude superior to past Navy Blimp LTA vehicles of the ZPG-2W size, although lower than the requirements of the helicopter spec.

AIRSPEED (KNOTS)	SIDESLIP ANGLE (DEG.)	SOURCE OF VALUES	LOADING CONDITION	PITCH	ROLL	YAW
				DEGREES ATTITUDE CHANGE IN ONE SECOND WITH FULL CONTROL DISPLACEMENT FROM TRIM		
0	N.A.	MIL-H-8501-A REQUIREMENT	ALL G.W.	3.52	1.77	6.45
		CALCULATED CONTROL RESPONSE	FULL DESIGN PAYLOAD	.58	1.81	3.69
			50% PAYLOAD	.83	2.39	2.32
25	AS NOTED →			0	90	0
				DEGREES ATTITUDE CHANGE IN ONE SECOND WITH FULL CONTROL DISPLACEMENT FROM TRIM		
		MIL-H-8501A REQUIREMENT	ALL G.W.	3.52	1.77	6.45
		CALCULATED CONTROL RESPONSE	FULL DESIGN PAYLOAD	.45	.21	3.36
			50% PAYLOAD	.66	NO TRIM	1.82

FIG. 22. COMPARISON OF MODEL C-76/.609 WITH HELICOPTER FLYING QUALITIES SPECIFICATION MIL-H-8501-A

6. CONCLUSIONS

A systematic investigation of controllability of hybrid LTA vehicles with varying ratios of static-lift to gross-weight and of longitudinal rotor spacing to overall length, has led to the following conclusions.

(1) Longitudinal translational acceleration has an inverse relationship to static-lift/gross-weight ratio.

(2) Longitudinal translational acceleration strongly depends on the amount of horizontal thrust. At high ratios of static-lift/gross-weight, horizontal thrust is the basic means of propulsion and control.

(3) Pitching acceleration has an inverse relationship with the static-lift/gross-weight ratio.

(4) Pitching acceleration increases with increasing longitudinal rotor spacing.

(5) At airspeeds up to at least 35 knots, the dependency of acceleration on speed, for either longitudinal translation or pitch, is minor, probably because of the relatively low body drag at these speeds. However, the dependency on speed becomes more significant at high ratios of static-lift/gross-weight, with acceleration decreasing with increasing speed.

6. CONCLUSIONS (Cont'd)

(6) Both lateral translational and roll acceleration have a strong inverse relationship with static-lift/gross-weight ratio and with lateral airspeed.

(7) Yaw acceleration has a strong inverse relationship to static-lift/gross-weight ratio.

(8) Except for high ratios of static-lift/gross-weight (greater than 0.85), an increasing rotor spacing results in a decrease in yaw acceleration.

(9) The use of horizontal thrust which can produce yawing moments is a highly effective method of increasing yaw maneuverability.

(10) Yaw acceleration capability depends on the relative instantaneous wind direction. For the configurations analyzed, with no stabilizing tail fins, the aerodynamic moment at an angle of yaw is high, becoming maximum at 45 degrees, and is a critical maneuverability condition for design.

6. <u>CONCLUSIONS</u> (Cont'd)

(11) The inverse relationship with static-lift/gross-weight ratio for pitch and roll acceleration, stated in conclusions (3) and (6), hold only for vehicles designed with thrusters limited in capacity consistent with their normal operation at high static-lift/gross-weight ratios. Vehicles with thrusters sized for operation at moderate to low static-lift/gross-weight ratio (not greater than 0.65) will have greater, not less, pitch and roll maneuverability when operating light (and thus at a higher static-lift/gross-weight ratio).

(12) The results herein can be useful in assessing the control response of a "real" hybrid LTA vehicle while still in the preliminary-design stage.

7. RECOMMENDATIONS

(1) The most complex of the hybrid configurations studied herein should be tested in full scale to correlate the actual versus calculated control reaction times and the resulting effect on required flight maneuvers.

(2) The flight maneuvers required for distinct aerial-crane mission functions should be broken down into flight segments, and the time for the hybrid configurations, used herein, to perform these segments should be calculated for each of the required flight maneuvers under various sets of assumed environmental conditions. The flight maneuvers contained in the following missions are of interest for such calculations:

a. Electrical transmission tower placement precision operations.

b. Containership (loading and unloading) precision shuttle operations.

c. Logging shuttle operations.

8. REFERENCES AND BIBLIOGRAPHY

NO.	REPORT NO.	CO. OR AGENCY	TITLE	AUTHOR	DATE
1.	97-X-11	Piasecki Aircraft	"Design Feasibility Analysis, Ultra-Heavy Vertical Lift System-The Heli-Stat"		24 June 76
2.			"Fluid Dynamic Drag"	S.F.Hoerner	1958
3.	Vol. VI	Dover Publications, Inc. New York, N.Y.	"Aerodynamic Theory"	W.F.Durand	1963
4.	MIL-H-8501A, Amend. 1	DOD	"Helicopter Flying and Ground Handling Qualities; General Requirements for"		3 Apr.1962

9. ABBREVIATIONS AND SYMBOLS

Symbols	Definition	Units
a	acceleration, linear	ft./sec.^{2}
C.B.	center of buoyancy	
C.G.	center of gravity	
C_D	drag coefficient, based on $\forall^{2/3}$	
C_L	lift coefficient, based on $\forall^{2/3}$	
C_M	moment coefficient, based on $\forall$	
℄	center-line	
cu. ft.	cubic feet	ft.^{3}
D	drag force	lb.
D	diameter	ft.
deg.	degrees	deg.
e.g.	for example	
F	Fahrenheit (temperature)	
fps	feet per second	ft./sec.
ft.	feet	ft.
f.r.	fineness ratio (length/diameter)	
g	acceleration of gravity	ft./sec.^{2}
G.W.	gross weight	lb.
H_{CG}	height of vehicle center of gravity (defined in Fig. 4)	ft.
H_{RTR}	height of main rotors (defined in Fig. 4)	ft.

9. ABBREVIATIONS AND SYMBOLS (Cont'd)

Symbols	Definition	Units
I_X, I_Y, I_Z	mass moment of inertia about X, Y and Z axes (roll, pitch, and yaw, respectively)	slug $ft.^2$
k_1	coefficient of additional apparent mass for longitudinal motion	
k_2	coefficient of additional apparent mass for transverse motion	
kt.	knots (speed)	kt.
L	lift	lb.
L	rolling moment	lb.-ft.
L	overall length	ft.
L_A	aerodynamic body lift	lb.
L_B	buoyant lift (synonymous with L_S)	lb.
lb.	pounds	lb.
L_S	static lift (synonymous with L_B)	lb.
LTA	lighter than air	
m	mass	slugs
M	pitching moment	lb.-ft.
min.	minutes	min.
min.	minimum	
N	yawing moment	lb.-ft.
p	rolling velocity	rad./sec.
psf	pounds per square foot	$lb./ft.^2$

9. ABBREVIATIONS AND SYMBOLS (Cont'd)

Symbols	Definition	Units
q	dynamic pressure = $1/2 \ V^2$	lb./ft.^{2}
q	pitching velocity	rad./sec.
r	yaw velocity	rad./sec.
R	radius	ft.
rad	radians	rad.
ref.	reference	
S	area	ft.^{2}
S.L.	sea level	
sec.	seconds	sec.
T	thrust	lb.
t	time	sec.
T_X, T_Y, T_Z	X, Y, Z components of rotor thrust (defined in Fig. 4)	lb.
T_{P_X}	X component of horizontal thrusters (defined in Fig. 4)	lb.
T_{R_Y}	Y component of horizontal thrusters (defined in Fig. 4)	lb.
U.L.	useful load	lb.
V	flight path velocity	ft./sec. or knots
v	sideslip velocity	ft./sec.
$\forall$	volume	ft.^{3}
W	gross weight	lb.

9. ABBREVIATIONS AND SYMBOLS (Cont'd)

Symbols	Definition	Units
X	direction of longitudinal axis	
x	displacement in X direction	ft.
X_{RTR}	rotor longitudinal spacing (defined in Fig. 4)	ft.
Y	direction of lateral axis	
y	displacement in Y direction (lateral)	ft.
Y_{RTR}	rotor lateral spacing (defined in Fig. 4)	ft.
α	angular acceleration	rad./sec.^{2}
β	sideslip angle	deg.
Δ	differential	
ρ	air density	slugs/ft.^{3}
ρ_e	average weight of aerostat envelope	lb./ft.^{2}
Φ	roll angle	rad
ψ	yaw angle	rad
$\dot{(\ )}$	first time derivative of ( )	sec.$^{-1}$
$\ddot{(\ )}$	second time derivative of ( )	sec.$^{-2}$

[illegible] [illegible]

[illegible] plus [illegible]

[illegible]

SUMMARY OF INERTIAL PROPERTIES OF VEHICLE CONFIGURATIONS

MODEL	GROSS WEIGHT		MASS OF HELIUM	MASS OF AIR IN BALLONETS (LESS DISPLACED HELIUM)	ADDITIONAL APPARENT MASS		TOTAL EQUIV. MASS	
					LONGITUDINAL MOTION	TRANSVERSE MOTION	LONGITUDINAL MOTION	TRANSVERSE MOTION
	(POUNDS)	(SLUGS)	(SLUGS)	(SLUGS)	(SLUGS)	(SLUGS)	(SLUGS)	(SLUGS)
97-1 (REF.)	321,600	9,988	958	1,546	826	5,578	13,328	18,030
A-134/.85	95,180	2,956	556	493	641	2,601	4,646	6,606
A-184/.609	132,900	4,127	556	493	641	2,601	5,817	7,777
A-184/.291	277,940	8,632	556	493	641	2,601	10,322	12,282
B-130/.85	95,180	2,956	556	493	641	2,601	4,646	6,606
B-130/.609	132,900	4,127	556	493	641	2,601	5,817	7,777
B-130/.291	277,940	8,632	556	493	541	2,601	10,322	12,282
C-76/.85	95,180	2,956	556	493	641	2,601	4,646	6,606
C-76/.609	132,900	4,127	556	493	641	2,601	5,817	7,777
C-76/.291	277,940	8,632	556	493	641	2,601	10,322	12,282

SUMMARY OF INERTIAL PROPERTIES OF VEHICLE CONFIGURATIONS (CONT'D)

MODEL	C.G. BELOW C.B. (FT.)	I_X (SLUG FT^2)	I_Y (SLUG FT^2)	I_Z (SLUG FT^2)	ADDITIONAL APPARENT MOMENT OF INERTIA IN PITCH AND YAW (SLUG FT^2)	TOTAL EQUIV. I_Y (SLUG FT^2)	TOTAL EQUIV. I_Z (SLUG FT^2)
97-1 (REF.)	33.3	37,433,000	137,085,000	149,421,000	9,529,000	146,614,000	160,620,000
A-184/.85	33.1	12,911,000	27,193,000	23,241,000	3,766,000	30,959,000	27,007,000
A-184/.609	39.2	17,763,000	37,209,000	26,174,000	3,766,000	40,975,000	29,940,000
A-184/.291	47.0	37,212,000	83,279,000	65,809,000	3,766,000	87,045,000	69,575,000
B-130/.85	33.7	14,295,000	20,921,000	17,801,000	3,766,000	24,687,000	21,567,000
B-130/.609	39.6	19,135,000	29,732,000	19,532,000	3,766,000	33,498,000	23,298,000
B-130/.291	47.3	41,490,000	62,804,000	48,922,000	3,766,000	66,570,000	52,688,000
C-76/.85	34.2	15,247,000	16,639,000	13,879,000	3,766,000	20,405,000	17,645,000
C-76/.609	40.1	20,025,000	25,600,000	14,757,000	3,766,000	29,365,000	18,523,000
C-76/.291	47.7	44,460,000	49,117,000	37,470,000	3,766,000	52,883,000	41,236,000

SUMMARY OF DRAG AREAS AND COEFFICIENTS, TOTAL VEHICLES

MODEL	VOLUME (FT3)	YAW ANGLE 0° DRAG AREA (FT2)	0° C_D	30° DRAG AREA (FT2)	30° C_D	60° DRAG AREA (FT2)	60° C_D	90° DRAG AREA (FT2)	90° C_D
97-1 (REF.)	2,900,000	1468	.0722	4980	.2450	17,300	.8500	22,000	1.082
C-76/.85	1,500,000	1133	.0865	3380	.2579	6,685	.5102	7,798	.5951
C-76/.609	1,500,000	1253	.0956	3460	.2640	6,770	.5166	7,918	.6043
C-76/.291	1,500,000	1433	.1094	3700	.2824	7,290	.5563	8,494	.6482
B-130/.85	1,500,000	1161	.0886	3450	.2633	6,870	.5243	8,068	.6157
B-130/.609	1,500,000	1281	.0978	3500	.2671	6,930	.5289	8,108	.6188
B-130/.291	1,500,000	1461	.1115	3820	.2915	7,480	.5708	8,764	.6688
A-184/.85	1,500,000	1176	.0897	3540	.2702	7,130	.5441	8,343	.6367
A-184/.609	1,500,000	1296	.0989	3580	.2732	7,230	.5518	8,463	.6456
A-184/.291	1,500,000	1476	.1126	3900	.2976	7,710	.5884	9,033	.6893

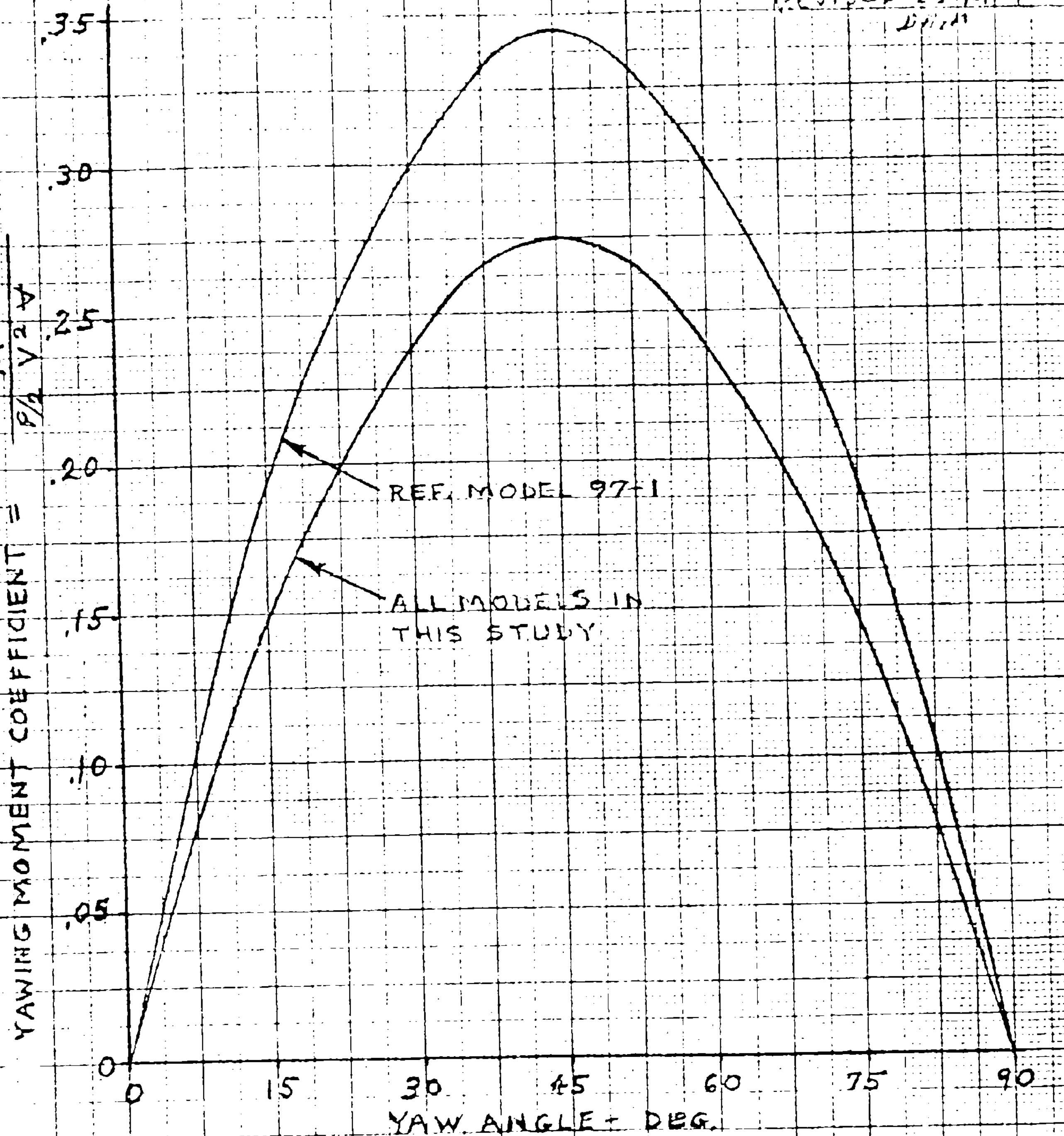
NOTE $C_D = \frac{\text{DRAG AREA}}{(\text{VOL})^{2/3}}$

SUMMARY OF TOTAL VEHICLE DRAGS

YAW ANGLE, DEG.	0				30			
SPEED - KNOTS	0	15	25	35	0	15	25	35
DYN. PRESS. - LB/FT^2	0	.7638	2.212	4.158	0	.7638	2.212	4.158
MODEL	DRAG (POUNDS)							
97-1 (REF)	0	1,121	3,247	6,103.	0	3,804	11,017	20,708
C-76/.85	0	865	2,505	4,709.		2,582	7,478	14,056.
C-76/.609	0	957	2,772	5,210.	0	2,643	7,654	14,388.
C-76/.291	0	1,095	3,171	5,961.	0	2,826	8,184	15,384.
B-130/.85	0	887	2,569	4,829.	0	2,635	7,631	14,345.
B-130/.609	0	978	2,832	5,324.	0	2,673	7,741	14,551.
B-130/.291	0	1,116	3,232	6,075.	0	2,918	8,451	15,885.
A-184/.85	0	898	2,601	4,889.	0	2,704	7,831	14,720.
A-184/.609	0	990	2,867	5,389.	0	2,734	7,918	14,883.
A-184/.291	0	1,127	3,264	6,135.	0	2,979	8,627	16,217.

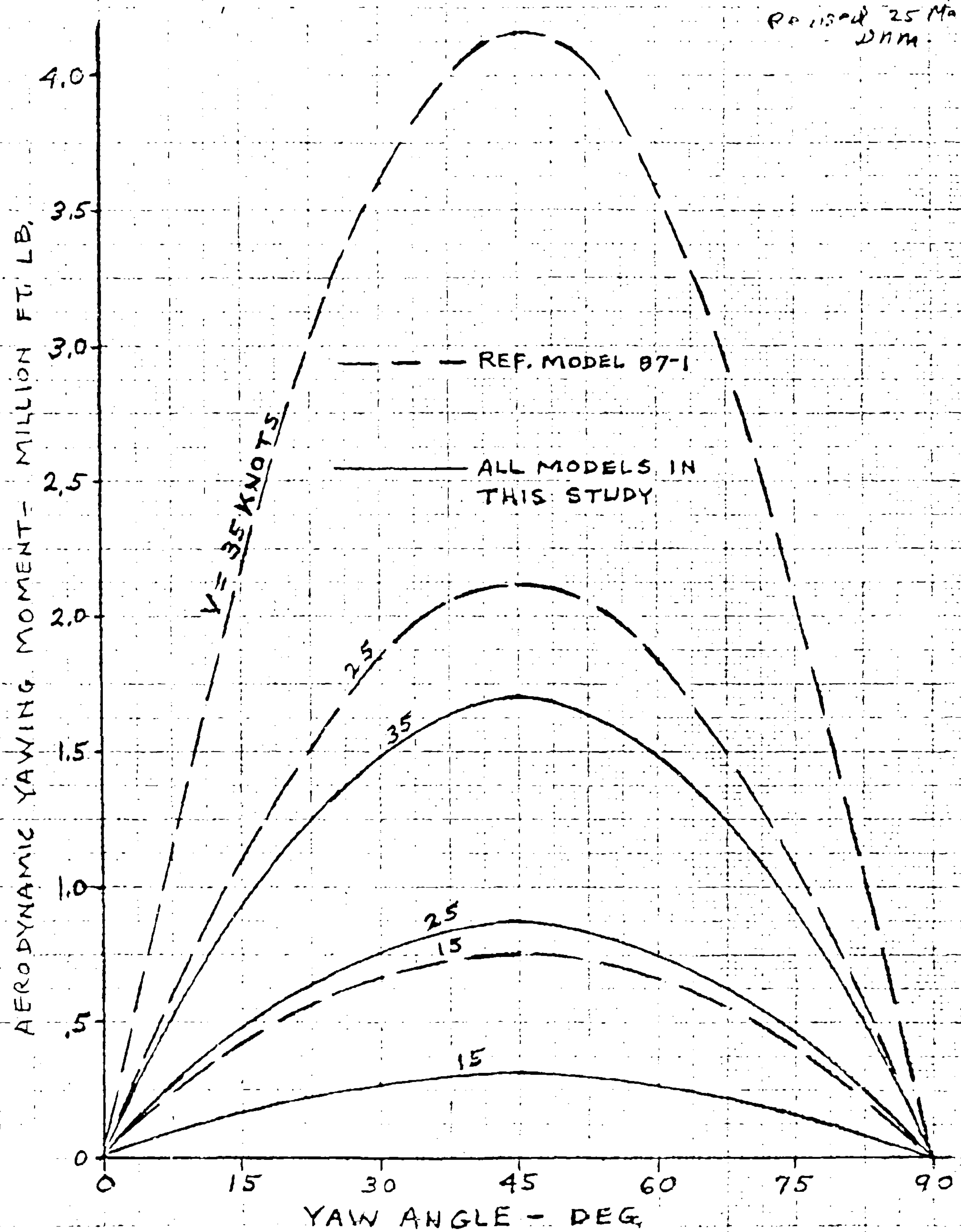
SUMMARY OF TOTAL VEHICLE DRAGS (CONT'D)

YAW ANGLE, DEG.	60				90			
SPEED - KNOTS	0	15	25	35	0	15	25	35
DYN. PRESS. - LB/FT^2	0	.7638	2.212	4.158	0	.7638	2.212	4/158
MODEL	DRAG (POUNDS)							
97-1 (REF.)	0	13,214	38,268	71,935	0	16,804	48,665	91,478
C-76/.85	0	5,106	14,787	27,796	0	5,956	17,249	32,423
C-76/.609	0	5,171	14,975	28,150	0	6,048	17,515	32,924
C-76/.291	0	5,568	16,125	30,311	0	6,488	28,790	35,320
B-130/.85	0	5,247	15,196	28,564	0	6,162	17,845	33,545
B-130/.609	0	5,293	15,329	28,814	0	6,193	17,935	33,714
B-130/.291	0	5,713	16,545	31,101	0	6,694	19,386	36,441
A-184/.85	0	5,446	15,772	29,647	0	6,372	18,454	34,688
A-184/.609	0	5,522	15,992	30,061	0	6,464	18,720	35,189
A-184/.291	0	5,889	17,055	32,059	0	6,899	19,980	37,557



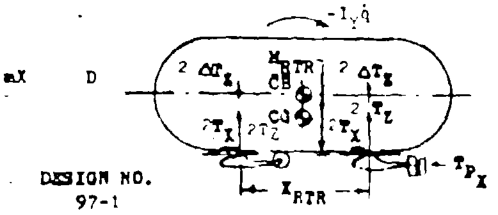
AERODYNAMIC YAWING MOMENT COEFFICIENT VS. YAW ANGLE

Revised 25 May 77
DHM



AERODYNAMIC YAWING MOMENT VS. YAW ANGLE

ACCELERATION IN PITCH AND LONGITUDINAL TRANSLATION

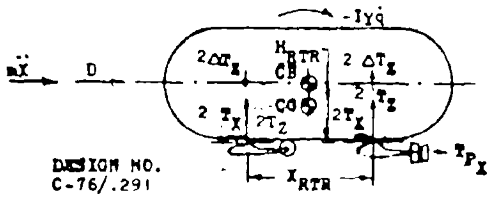


DESIGN NO. 97-1

H_{RTR}	=	37.0	FT.
X_{RTR}	=	295.25	FT.
$T_{X_{MAX}}$	=	9,608	LB.
$(\Delta T_Z)_{MAX}$	=	13,560	LB.
m	=	13,378	SLUGS
I_Y	=	146,614,000	SL. FT.^{2}

	VELOCITY (V)	KT.	0	15	25	35
	DYNAMIC PRESS. (q)	P.S.F.	0	.764	2.12	4.16
	DRAG (D)	LB.	0	1,121	3,247	6,103
	$\Delta T_{Z_{TRIM}} = \frac{D(H_{RTR})}{2(X_{RTR})}$	LB.	0	70	203	382
	$\alpha_Y = \frac{2(\Delta T_{Z_{MAX}} - \Delta T_{Z_{TRIM}})(X_{RTR})}{I_Y}$	$\frac{RAD.}{SEC^2}$	.0546	.0543	.0538	.0531
$T_{P_{X_{MAX}}}$ =	$(4\,T_X + T_{P_X})_{MAX}$	LB.	38,432	38,432	38,432	38,432
0 LB.	$(4\,T_X + T_{P_X})_{MAX} - D$	LB.	38,432	37,311	35,185	32,329
	$\ddot{X} = \frac{(4\,T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	2.88	2.80	2.64	2.43
$T_{P_{X_{MAX}}}$ =	$(4\,T_X + T_{P_X})_{MAX}$	LB.				
LB.	$(4\,T_X + T_{P_X})_{MAX} - D$	LB.				
	$\ddot{X} = \frac{(4\,T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$				
$T_{P_{X_{MAX}}}$ =	$(4\,T_X + T_{P_X})_{MAX}$	LB.				
LB.	$(4\,T_X + T_{P_X})_{MAX} - D$	LB.				
	$\ddot{X} = \frac{(4\,T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$				
$T_{P_{X_{MAX}}}$ =	$(4\,T_X + T_{P_X})_{MAX}$	LB.				
LB.	$(4\,T_X + T_{P_X})_{MAX} - D$	LB.				
	$\ddot{X} = \frac{(4\,T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$				

ACCELERATION IN PITCH AND LONGITUDINAL TRANSLATION

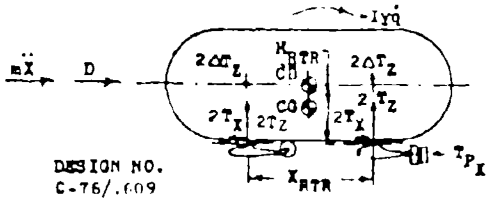


DESIGN NO.
C-76/.291

H_{RTR}	= 49.0	FT.
X_{RTR}	= 76	FT.
$T_{X_{MAX}}$	= 10,470	LB.
$(\Delta T_Z)_{MAX}$	= 14,778	LB.
m	= 10,322	SLUGS
I_Y	= 52,883,000	SL. FT.^{2}

	VELOCITY (V)	KT.	0	15	25	35
	DYNAMIC PRESS. (q)	P.S.F.	0	.764	2.12	4.16
	DRAG (D)	LB.	0	1,095	3,171	5,961
	$\Delta T_{Z_{TRIM}} = \frac{D(H_{RTR})}{2(X_{RTR})}$	LB.	0	353	1,022	1,922
	$\alpha_Y = \frac{2(\Delta T_{Z_{MAX}} - \Delta T_{Z_{TRIM}})(X_{RTR})}{I_Y}$	$\frac{RAD.}{SEC^2}$	.0425	.0415	.0395	.0370
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	47,790	47,790	47,790	47,790
5,910 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	47,790	46,695	44,619	41,829
	$\ddot{X} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	4.63	4.52	4.32	4.05
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	66,480	66,480	66,480	66,480
24,600 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	66,480	65,385	63,309	60,519
	$\ddot{X} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	6.44	6.33	6.13	5.86
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	140,400	140,400	140,400	140,400
98,520 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	140,400	139,305	137,229	134,439
	$\ddot{X} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	13.60	13.50	13.29	13.02
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	238,920	238,920	238,920	238,920
197,040 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	238,920	237,825	235,749	232,959
	$\ddot{X} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	23.14	23.04	22.84	22.57

ACCELERATION IN PITCH AND LONGITUDINAL TRANSLATION

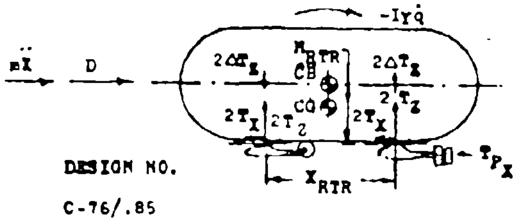


DESIGN NO.
C-76/.609

H_{RTR}	=	49.0	FT.
X_{RTR}	=	76	FT.
$T_{X_{MAX}}$	=	2,763	LB.
$(\Delta T_Z)_{MAX}$	=	3,900	LB.
m	=	5,81[illegible]	SLUGS
I_Y	=	[illegible]	SL. FT.^{2}

	VELOCITY (V)	KT.	0	15	25	35
	DYNAMIC PRESS. (q)	P.S.F.	0	.764	2.12	4.16
	DRAG (D)	LB.	0	957	2,772	5,210
	$\Delta T_{Z_{TRIM}} = \frac{D(H_{RTR})}{2(X_{RTR})}$	LB.	0	309	894	1,680
	$\alpha_Y = \frac{2(\Delta T_{Z_{MAX}} - \Delta T_{Z_{TRIM}})(X_{RTR})}{I_Y}$	$\frac{RAD.}{SEC^2}$	.0202	.0186	.0156	.0115
$T_{P_{X_{MAX}}}$ = 1,560 LB.	$(4\ T_X + T_{P_X})_{MAX}$	LB.	12,612	12,612	12,612	12,612
	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	12,612	11,655	9,840	7,402
	$\ddot{x} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	2.17	2.00	1.692	1.272
$T_{P_{X_{MAX}}}$ = 6,500 LB.	$(4\ T_X + T_{P_X})_{MAX}$	LB.	17,552	17,552	17,552	17,552
	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	17,552	16,595	14,780	12,342
	$\ddot{x} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	3.02	2.85	2.54	2.12
$T_{P_{X_{MAX}}}$ = 26,000 LB.	$(4\ T_X + T_{P_X})_{MAX}$	LB.	37,052	37,052	37,052	37,052
	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	37,052	36,095	34,280	31,842
	$\ddot{x} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	6.370	6.205	5.893	5.474
$T_{P_{X_{MAX}}}$ = 52,000 LB.	$(4\ T_X + T_{P_X})_{MAX}$	LB.	63,052	63,052	63,052	63,052
	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	63,052	62,095	60,280	57,842
	$\ddot{x} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	10.84	10.67	10.36	9.94

ACCELERATION IN PITCH AND LONGITUDINAL TRANSLATION



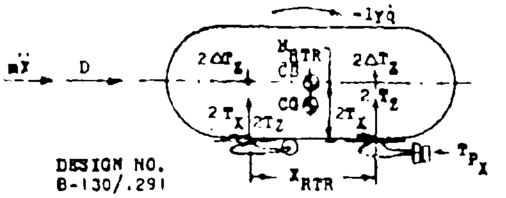
DESIGN NO.

C-76/.85

H_{RTR}	=	49.0	FT.
X_{RTR}	=	76	FT.
$T_{X_{MAX}}$	=	759	LB.
$(\Delta T_Z)_{MAX}$	=	1,071	LB.
m	=	4,646	SLUGS
I_Y	=	20,405,000	SL. FT.^{2}

	VELOCITY (V)	KT.	0	15	25	35
	DYNAMIC PRESS. (q)	P.S.F.	0	.764	2.12	4.16
	DRAG (D)	LB.	0	865	2505	4709
	$\Delta T_{Z_{TRIM}} = \frac{D(H_{RTR})}{2(X_{RTR})}$	LB.	0	279	808	1518
	$\alpha_Y = \frac{2(\Delta T_{Z_{MAX}} - \Delta T_{Z_{TRIM}})(X_{RTR})}{I_Y}$	$\frac{RAD.}{SEC^2}$	.0080	.0059	.0020	—
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	3,464	3,464	3,464	3,464
428 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	3,464	2,599	959	-1245
	$\ddot{X} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	.745	.559	.206	-.268
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	4,821	4,821	4,821	4,821
1,785 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	4,821	3,956	2,316	112
	$\ddot{X} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	1.038	.851	.498	.024
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	10,176	10,176	10,176	10,176
7,140 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	10,176	9,311	7,671	5,467
	$\ddot{X} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	2,190	2.004	1,651	1,177
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	17,316	17,316	17,316	17,316
14,280 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	17,316	16,451	14,811	12,607
	$\ddot{X} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	3.727	3.541	3.188	2.714

ACCELERATION IN PITCH AND LONGITUDINAL TRANSLATION

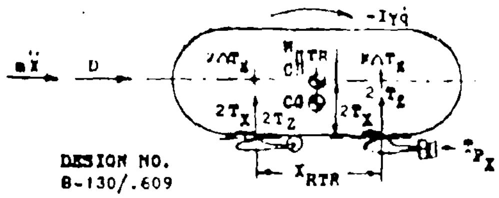


DESIGN NO.
B-130/.291

H_{RTR}	=	49.0	FT.
X_{RTR}	=	130	FT.
$T_{X_{MAX}}$	=	10,470	LB.
$(\Delta T_Z)_{MAX}$	=	14,778	LB.
m	=	10,322	SLUGS
I_Y	=	66,570,000	SL. FT.^{2}

	VELOCITY (V)	KT.	0	15	25	35
	DYNAMIC PRESS. (q)	P.S.F.	0	.764	2.12	4.16
	DRAG (D)	LB.	0	1,116	3,232	6,075
	$\Delta T_{Z_{TRIM}} = \frac{D(H_{RTR})}{2(X_{RTR})}$	LB.	0	210	609	1,145
	$\alpha_Y = \frac{2(\Delta T_{Z_{MAX}} - \Delta T_{Z_{TRIM}})(X_{RTR})}{I_Y}$	$\frac{RAD.}{SEC^2}$	.0577	.0569	.0553	.0532
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	47,790	47,790	47,790	47,790
5,910 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	47,790	46,674	44,558	41,715
	$\ddot{x} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	4.63	4.52	4.32	4.04
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	66,480	66,480	66,480	66,480
24,600 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	66,480	65,364	63,249	60,405
	$\ddot{x} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	6.44	6.33	6.13	5.85
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	238,920	238,920	238,920	238,920
197,040 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	238,920	237,804	235,688	232,845
	$\ddot{x} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	23.15	23.04	22.83	22.56
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.				
LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.				
	$\ddot{x} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$				

ACCELERATION IN PITCH AND LONGITUDINAL TRANSLATION

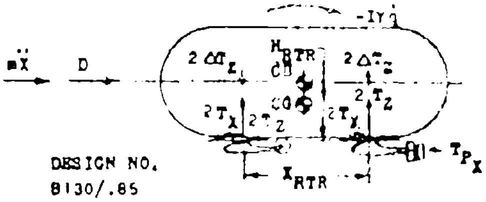


DESIGN NO.
B-130/.609

H_{RTR}	=	49.0	FT.
X_{RTR}	=	130	FT.
$T_{X_{MAX}}$	=	2,763	LB.
$(\Delta T_Z)_{MAX}$	=	3,900	LB.
m	=	5,817	SLUGS
I_Y	=	33,498,000	SL. FT.^{2}

	VELOCITY (V)	KT.	0	15	25	35
	DYNAMIC PRESS. (q)	P.S.F.	0	.764	2.12	4.16
	DRAG (D)	LB.	0	978	2,832	5,324
	$\Delta T_{Z_{TRIM}} = \frac{D(H_{RTR})}{2(X_{RTR})}$	LB.	0	184	534	1,003
	$\alpha_Y = \frac{2(\Delta T_{Z_{MAX}} - \Delta T_{Z_{TRIM}})(X_{RTR})}{I_Y}$	$\frac{RAD.}{SEC^2}$	.0303	.0288	.0201	.0225
$T_{P_{X_{MAX}}}$ =	$(4\,T_X + T_{P_X})_{MAX}$	LB.	12,612	12,612	12,612	12,612
1,560 LB.	$(4\,T_X + T_{P_X})_{MAX} - D$	LB.	12,612	11,634	9,780	7,288
	$\ddot{x} = \frac{(4\,T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	2.17	2.00	1.681	1.253
$T_{P_{X_{MAX}}}$ =	$(4\,T_X + T_{P_X})_{MAX}$	LB.	17,552	17,552	17,552	17,552
6,500 LB.	$(4\,T_X + T_{P_X})_{MAX} - D$	LB.	17,552	16,574	14,720	12,228
	$\ddot{x} = \frac{(4\,T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	3.02	2.85	2.53	2.10
$T_{P_{X_{MAX}}}$ =	$(4\,T_X + T_{P_X})_{MAX}$	LB.	63,052	63,052	63,052	63,052
52,000 LB.	$(4\,T_X + T_{P_X})_{MAX} - D$	LB.	63,052	62,074	60,220	57,728
	$\ddot{x} = \frac{(4\,T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	10.83	10.67	10.35	9.92
$T_{P_{X_{MAX}}}$ =	$(4\,T_X + T_{P_X})_{MAX}$	LB.				
LB.	$(4\,T_X + T_{P_X})_{MAX} - D$	LB.				
	$\ddot{x} = \frac{(4\,T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$				

ACCELERATION IN PITCH AND LONGITUDINAL TRANSLATION

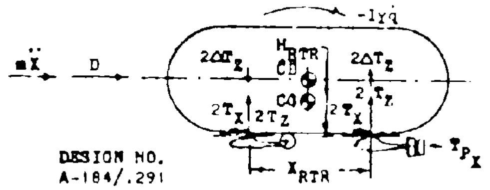


DESIGN NO.
8130/.85

H_{RTR} = 45.0 FT.
X_{RTR} = 130 FT.
$T_{X_{MAX}}$ = 759 LB.
$(\Delta T_Z)_{MAX}$ = 1,071 LB.
m = 4,646 SLUGS
I_Y = 24,687,000 SL. FT.^{2}

	VELOCITY (V)	KT.	0	15	25	35
	DYNAMIC PRESS. (q)	P.S.F.	0	.764	2.12	4.16
	DRAG (D)	LB.	0	087	2,569	4,829
	$\Delta T_{Z_{TRIM}} = \frac{D(H_{RTR})}{2(X_{RTR})}$	LB.	0	167	464	910
	$\alpha_Y = \frac{2(\Delta T_{Z_{MAX}} - \Delta T_{Z_{TRIM}})(X_{RTR})}{I_Y}$	$\frac{RAD.}{SEC^2}$	.0113	.0095	.0062	.0017
$T_{P_{X_{MAX}}}$ =	$(4\,T_X + T_{P_X})_{MAX}$	LB.	3,464	3,464	3,464	3,464
428 LB.	$(4\,T_X + T_{P_X})_{MAX} - D$	LB.	3,464	2,577	895	-1,365
	$\ddot{x} = \frac{(4\,T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	.748	.557	.193	-.295
$T_{P_{X_{MAX}}}$ =	$(4\,T_X + T_{P_X})_{MAX}$	LB.	4,821	4,821	4,821	4,821
1,785 LB.	$(4\,T_X + T_{P_X})_{MAX} - D$	LB.	4,821	3,934	2,252	-8
	$\ddot{x} = \frac{(4\,T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	1.042	.850	.487	-.002
$T_{P_{X_{MAX}}}$ =	$(4\,T_X + T_{P_X})_{MAX}$	LB.	17,316	17,316	17,316	17,316
14,280 LB.	$(4\,T_X + T_{P_X})_{MAX} - D$	LB.	17,316	16,429	14,747	12,487
	$\ddot{x} = \frac{(4\,T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	3.743	3.551	3.188	2.699
$T_{P_{X_{MAX}}}$ =	$(4\,T_X + T_{P_X})_{MAX}$	LB.				
LB.	$(4\,T_X + T_{P_X})_{MAX} - D$	LB.				
	$\ddot{x} = \frac{(4\,T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$				

ACCELERATION IN PITCH AND LONGITUDINAL TRANSLATION

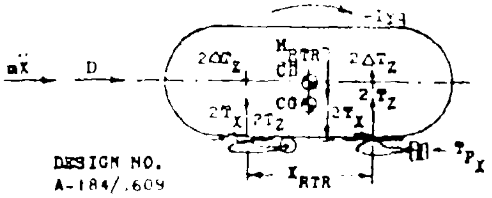


DESIGN NO.
A-184/.291

H_{RTR}	=	49.0	FT.
X_{RTR}	=	184	FT.
$T_{X_{MAX}}$	=	10,470	LB.
$(\Delta T_Z)_{MAX}$	=	14,778	LB.
m	=	10,322	SLUGS
I_Y	=	87,045,000	SL. FT.^{2}

	VELOCITY (V)	KT.	0	15	25	35
	DYNAMIC PRESS. (q)	P.S.F.	0	.764	2.12	4.16
	DRAG (D)	LB.	0	1,127	3,264	6,135
	$\Delta T_{Z_{TRIM}} = \frac{D(H_{RTR})}{2(X_{RTR})}$	LB.	0	150	435	817
	$\alpha_Y = \frac{2(\Delta T_{Z_{MAX}} - \Delta T_{Z_{TRIM}})(X_{RTR})}{I_Y}$	$\frac{RAD.}{SEC^2}$	.0625	.0648	.0605	.0590
$T_{P_{X_{MAX}}}$ =	$(4T_X + T_{P_X})_{MAX}$	LB.	47,790	47,790	47,790	47,790
5,910 LB.	$(4T_X + T_{P_X})_{MAX} - D$	LB.	47,790	46,663	44,526	41,655
	$\ddot{X} = \frac{(4T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	4.63	4.52	4.31	4.04
$T_{P_{X_{MAX}}}$ =	$(4T_X + T_{P_X})_{MAX}$	LB.	66,480	66,480	66,480	66,480
24,600 LB.	$(4T_X + T_{P_X})_{MAX} - D$	LB.	66,480	65,353	63,216	60,345
	$\ddot{X} = \frac{(4T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	6.44	6.33	6.12	5.85
$T_{P_{X_{MAX}}}$ =	$(4T_X + T_{P_X})_{MAX}$	LB.	238,920	238,920	238,920	238,920
197,040 LB.	$(4T_X + T_{P_X})_{MAX} - D$	LB.	238,920	237,793	235,655	232,785
	$\ddot{X} = \frac{(4T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	23.15	23.04	22.83	22.55
$T_{P_{X_{MAX}}}$ =	$(4T_X + T_{P_X})_{MAX}$	LB.				
LB.	$(4T_X + T_{P_X})_{MAX} - D$	LB.				
	$\ddot{X} = \frac{(4T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$				

ACCELERATION IN PITCH AND LONGITUDINAL TRANSLATION

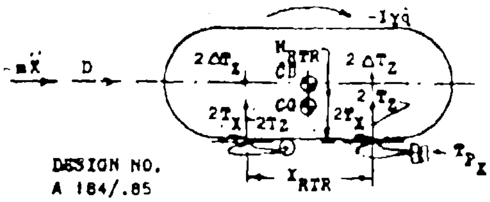


DESIGN NO.
A-184/.609

H_{RTR}	= 49.0	FT.
X_{RTR}	= 184	FT.
$T_{X_{MAX}}$	= 2,763	LB.
$(\Delta T_Z)_{MAX}$	= 3,900	LB.
m	= 5,817	SLUGS
I_Y	= 40,975,000	SL. FT.^{2}

	VELOCITY (V)	KT.	0	15	25	35
	DYNAMIC PRESS. (q)	P.S.F.	0	.764	2.12	4.16
	DRAG (D)	LB.	0	990	2,867	5,389
	$\Delta T_{Z_{TRIM}} = \frac{D(H_{RTR})}{2(X_{RTR})}$	LB.	0	132	382	718
	$\alpha_Y = \frac{2(\Delta T_{Z_{MAX}} - \Delta T_{Z_{TRIM}})(X_{RTR})}{I_Y}$	$\frac{RAD.}{SEC^2}$	.0350	.0338	.0316	.0286
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	12,612	12,612	12,612	12,612
1,560 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	12,612	11,172	9,295	6,773
	$\ddot{X} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	2.17	1.921	1.598	1.184
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	17,552	17,552	17,552	17,552
6,500 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	17,552	16,562	14,685	12,163
	$\ddot{X} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	3.02	2.85	2.52	2.09
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	63,052	63,052	63,052	63,052
52,000 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	63,052	62,062	60,185	57,663
	$\ddot{X} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	10.84	10.67	10.35	9.91
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.				
LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.				
	$\ddot{X} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$				

ACCELERATION IN PITCH AND LONGITUDINAL TRANSLATION

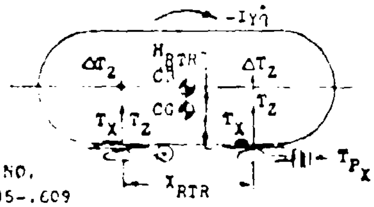


DESIGN NO.
A 184/.85

H_{RTR}	= 49.0	FT.
X_{RTR}	= 184	FT.
$T_{X_{MAX}}$	= 759	LB.
$(\Delta T_Z)_{MAX}$	= 1,071	LB.
m	= 4,646	SLUGS
I_Y	= 30,959,000	SL. FT.^{2}

	VELOCITY (V)	KT.	0	15	25	35
	DYNAMIC PRESS. (q)	P.S.F.	0	.764	2.12	4.16
	DRAG (D)	LB.	0	838	2,601	4,889
	$\Delta T_{Z_{TRIM}} = \frac{D(H_{RTR})}{2(X_{RTR})}$	LB.	0	120	346	651
	$\ddot{\alpha}_Y = \frac{2(\Delta T_{Z_{MAX}} - \Delta T_{Z_{TRIM}})(X_{RTR})}{I_Y}$	$\frac{RAD.}{SEC^2}$	.0127	.0113	.0086	.0050
$T_{P_{X_{MAX}}}$ =	$(4\,T_X + T_{P_X})_{MAX}$	LB.	3,464	3,464	3,464	3,464
428 LB.	$(4\,T_X + T_{P_X})_{MAX} - D$	LB.	3,464	2,566	863	-1,425
	$\ddot{X} = \frac{(4\,T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	.746	.552	.186	-.307
$T_{P_{X_{MAX}}}$ =	$(4\,T_X + T_{P_X})_{MAX}$	LB.	4,821	4,821	4,821	4,821
1,785 LB.	$(4\,T_X + T_{P_X})_{MAX} - D$	LB.	4,821	3,923	2,220	-68
	$\ddot{X} = \frac{(4\,T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	1.038	.844	.478	-.015
$T_{P_{X_{MAX}}}$ =	$(4\,T_X + T_{P_X})_{MAX}$	LB.	17,316	17,316	17,316	17,316
14,280 LB.	$(4\,T_X + T_{P_X})_{MAX} - D$	LB.	17,316	16,418	14,715	12,427
	$\ddot{X} = \frac{(4\,T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	3.727	3.534	3.167	2.675
$T_{P_{X_{MAX}}}$ =	$(4\,T_X + T_{P_X})_{MAX}$	LB.				
LB.	$(4\,T_X + T_{P_X})_{MAX} - D$	LB.				
	$\ddot{X} = \frac{(4\,T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$				

ACCELERATION IN PITCH AND LONGITUDINAL TRANSLATION

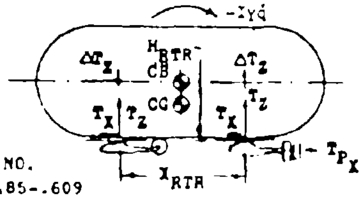


DESIGN NO.
C-76/.85-.609

H_{RTR} =	49.0	FT.
X_{RTR} =	76	FT.
$T_{X_{MAX}}$ =	759	LB.
$(\Delta T_Z)_{MAX}$ =	3,900	LB.
m =	4,646	SLUGS
I_Y =	20,405,000	SL. FT.^{2}

	VELOCITY (V)	KT.	0	15	25	35
	DYNAMIC PRESS. (q)	P.S.F.	0	.764	2.12	4.16
	DRAG (D)	LB.	0	865	2,505	4,709
	$\Delta T_{Z_{TRIM}} = \frac{D(H_{RTR})}{2(X_{RTR})}$	LB.	0	279	808	1,518
	$\alpha_Y = \frac{2(\Delta T_{Z_{MAX}} - \Delta T_{Z_{TRIM}})(X_{RTR})}{I_Y}$	$\frac{RAD.}{SEC^2}$	.0291	.0270	.0230	.0177
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	[illegible]	[illegible]	[illegible]	[illegible]
1,560 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	4,596	3,731	2,091	-113
	$\ddot{x} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	.989	.803	.450	-.024
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	9,536	9,536	9,536	9,536
6,500 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	9,536	8,671	7,031	4,827
	$\ddot{x} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	2.053	1.867	1.513	1.039
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	29,036	29,036	29,036	29,036
26,000 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	29,036	28,171	26,531	24,327
	$\ddot{x} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	6.250	6.064	5.711	5.236
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	55,036	55,036	55,036	55,036
52,000 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	55,036	54,171	52,531	50,327
	$\ddot{x} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	11.846	11.660	11.307	10.832

ACCELERATION IN PITCH AND LONGITUDINAL TRANSLATION

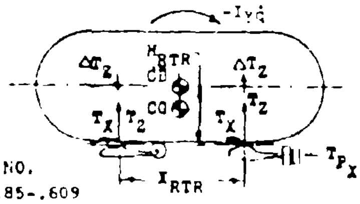


DESIGN NO.
8-130/.85-.609

H_{RTR}	=	49.0	FT.
X_{RTR}	=	130	FT.
$T_{X_{MAX}}$	=	759	LB.
$(\Delta T_Z)_{MAX}$	=	3,900	LB.
m	=	4,646	SLUGS
I_Y	=	24,687,000	SL. FT.^{2}

	VELOCITY (V)	KT.	0	15	25	35
	DYNAMIC PRESS. (q)	P.S.F.	0	.764	2.12	4.16
	DRAG (D)	LB.	0	887	2,569	4,829
	$\Delta T_{Z_{TRIM}} = \frac{D(H_{RTR})}{2(X_{RTR})}$	LB.	0	167	484	910
	$\alpha_Y = \frac{2(\Delta T_{Z_{MAX}} - \Delta T_{Z_{TRIM}})(X_{RTR})}{I_Y}$	$\frac{RAD.}{SEC^2}$	.0411	.0393	.0360	.0315
$T_{P_{X_{MAX}}}$ = 1,560 LB.	$(4\ T_X + T_{P_X})_{MAX}$	LB.	4,596	4,596	4,596	4,596
	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	4,595	3,709	2,027	-233
	$\ddot{x} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	.983	.798	.436	-.050
$T_{P_{X_{MAX}}}$ = 6,500 LB.	$(4\ T_X + T_{P_X})_{MAX}$	LB.	9,536	9,536	9,536	9,536
	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	9,536	8,649	6,967	4,707
	$\ddot{x} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	2.053	1.862	1.50	1.01
$T_{P_{X_{MAX}}}$ = 26,000 LB.	$(4\ T_X + T_{P_X})_{MAX}$	LB.	29,036	29,036	29,036	29,036
	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	29,036	28,159	26,467	24,207
	$\ddot{x} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	6.25	6.06	5.70	5.21
$T_{P_{X_{MAX}}}$ = 52,000 LB.	$(4\ T_X + T_{P_X})_{MAX}$	LB.	55,036	55,036	55,036	55,036
	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	55,036	54,149	52,467	50,207
	$\ddot{x} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	11.85	11.65	11.29	10.81

ACCELERATION IN PITCH AND LONGITUDINAL TRANSLATION



DESIGN NO.
A-184/.85-.609

H_{RTR}	=	49.0	FT.
X_{RTR}	=	184	FT.
$T_{X_{MAX}}$	=	759	LB.
$(\Delta T_Z)_{MAX}$	=	3,900	LB.
m	=	4,646	SLUGS
I_Y	=	30,959,000	SL. FT.^{2}

	VELOCITY (V)	KT.	0	15	25	35
	DYNAMIC PRESS. (q)	P.S.F.	0	.764	2.12	4.16
	DRAG (D)	LB.	0	898	2,601	4,889
	$\Delta T_{Z_{TRIM}} = \frac{D(H_{RTR})}{2(X_{RTR})}$	LB.	0	120	346	651
	$\alpha_Y = \frac{2(\Delta T_{Z_{MAX}} - \Delta T_{Z_{TRIM}})(X_{RTR})}{I_Y}$	$\frac{RAD.}{SEC^2}$	.046	.045	.042	.039
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	4,596	4,596	4,596	4,596
1,560 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	4,596	3,698	1,995	-293
	$\ddot{x} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	.99	.80	.43	-.063
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	9,536	9,536	9,536	9,536
6,500 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	9,536	8,638	6,935	4,647
	$\ddot{x} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	2.05	1.86	1.49	1.00
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	29,036	29,036	29,036	29,036
26,000 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	29,036	28,138	26,435	24,147
	$\ddot{x} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	6.25	6.06	5.70	5.20
$T_{P_{X_{MAX}}}$ =	$(4\ T_X + T_{P_X})_{MAX}$	LB.	55,036	55,036	55,036	55,036
52,000 LB.	$(4\ T_X + T_{P_X})_{MAX} - D$	LB.	55,036	54,138	52,435	50,147
	$\ddot{x} = \frac{(4\ T_X + T_{P_X})_{MAX} - D}{m}$	$\frac{FT.}{SEC^2}$	11.85	11.65	11.29	10.79

Equations of Motion for Lateral Translation and Roll.

Maximum roll acceleration is produced when T_Y, T_{R_Y}, and T_Z are co-ordinated to produce pure roll (zero lateral translation acceleration). Therefore, for $\ddot{y} = 0$,

$\Sigma Y = 0.$

$$\sin \phi = \frac{D - 4T_{Y_{max}} - 2\,T_{R_{Y_{max}}}}{4T_Z}$$

If ϕ is calculated to be negative, the vehicle can be trimmed at the particular lateral velocity in level attitude and need not be banked. Therefore, in such a case ϕ is made equal to zero.

$\Sigma M_Y = 0.$

$$\Delta T_{Z_{trim}} = \frac{D(H_{rtr}) + (L_B\,H_{rtr} - WH_{cg})\sin\phi}{2Y_{rtr}}$$

$$\dot{p} = \frac{2Y_{rtr}\Delta T_{Z_{max}} - DH_{rtr} - \sin\phi\,(L_B H_{rtr} - WH_{cg})}{I_X}$$

Maximum lateral linear acceleration is produced when T_Y, T_{R_Y}, and T_Z are coordinated to produce pure linear motion (zero roll acceleration). Therefore, for $\dot{p} = 0$,

$\Sigma Y = 0.$

$$\sin \phi = \frac{D + m\ddot{y} - 4T_{Y_{max}} - 2T_{R_{Y_{max}}}}{4T_Z} \qquad (1)$$

$\Sigma M_Y = 0.$

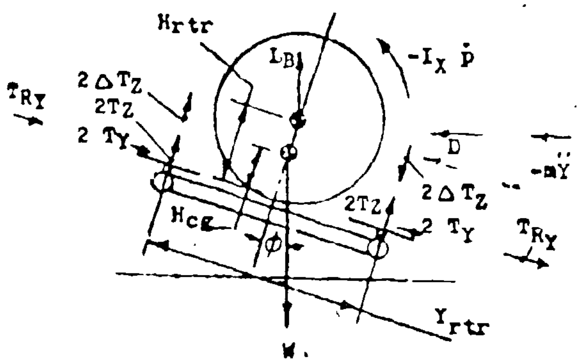
$$\sin \phi = \frac{2\,\Delta T_{Z_{max}} Y_{rtr} - H_{rtr}(D + m\ddot{y})}{L_B\,H_{rtr} - WH_{cg}} \qquad (2)$$

Combining (1) and (2) and simplifying:

$$\ddot{y} = \frac{4T_Z(2\Delta T_{Z_{max}} Y_{rtr} - DH_{rtr}) + (WH_{cg} - L_B H_{rtr})(D - 4T_{Y_{max}} - 2T_{R_{Y_{max}}})}{m(4T_Z H_{rtr} + L_B H_{rtr} - WH_{cg})}$$

ACCEL ATION IN LATERAL TRANSLATION AND ROLL

Ψ = 90 DEG.



H_{rtr}	=	49.0	ft.
H_{cg}	=	-4.5	ft.
$T_{Y_{max}}$	=	10,470	lb.
$\Delta T_{Z_{max}}$	=	14,778	lb.
m	=	12,282	slugs
I_X	=	44,460,000	slug ft.^{2}
T_Z	=	49,260	lb.
L_B	=	80,900	lb.
W	=	277,940	lb.
Y_{rtr}	=	163	ft.
$T_{R_{Y_{max}}}$	=	750	lb.

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$c_1 = (L_B\, H_{rtr}) - (W\, H_{cg}) = 5,214,830$ ft. lb.

$c_2 = 2\, Y_{rtr}\, (\Delta T_{Z_{max}}) = 4,817,628$ ft. lb.

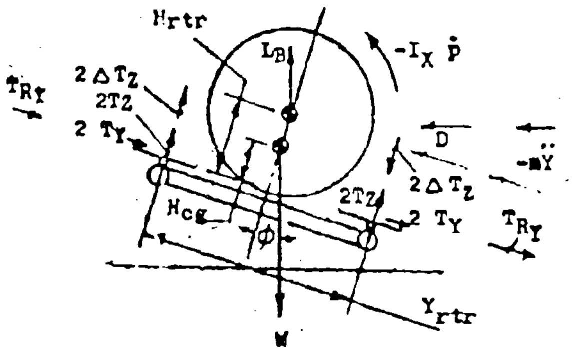
$c_3 = 4\, T_Z\, H_{rtr} + c_1 = 14,669,790$ ft. lb.

V	= Velocity (sidewards)	kt.	0	15	25	35
D	= Drag	lb.	0	6,488	18,790	35,320
ε_1	$= D - 4T_{Y_{max}} - 2T_{R_{Y_{max}}}$	lb.	-43,380	-36,892	-24,590	-8,060
*$\sin\phi$	$= \dfrac{\varepsilon_1}{4T_Z}$	-	0	0	0	0
ε_2	$= D\,(H_{rtr})$	1,000 ft. lb.	0	317.9	920.7	1,730.7
ε_3	$= c_2 - \varepsilon_2$	10^6 ft. lb.	4.818	4.500	3.897	3.087
$\dot p$	$= \dfrac{\varepsilon_3 - c_1 \sin\phi}{I_X}$	rad./sec.^{2}	.1084	.1012	.0876	.0694
ε_4	$= 4\, T_Z\, (\varepsilon_3) - c_1\, (\varepsilon_1)$	10^{10} ft. lb^2	117.55	107.90	89.608	65.028
$\ddot Y$	$= \dfrac{\varepsilon_4}{m\,(c_3)}$	ft./sec.^{2}	6.436	5.908	4.907	3.561

* If $\sin\phi \lesseqgtr 0$, make it = 0. Negative $\sin\phi$ indicates that the lateral control force components available are more than sufficient to counteract the lateral drag at a roll angle (ϕ) = 0.

ACCELERATION IN LATERAL TRANSLATION AND ROLL

ψ = 90 DEG.



H_{rtr}	=	49.0	ft.
H_{cg}	=	8.9	ft.
$T_{Y_{max}}$	=	2,763	lb.
$\Delta T_{Z_{max}}$	=	3,900	lb.
m	=	7,777	slugs
I_X	=	20,025,000	slug ft.^{2}
T_Z	=	13,000	lb.
L_B	=	80,900	lb.
W	=	132,900	lb.
Y_{rtr}	=	163	ft.
$T_{R_{Y_{max}}}$	=	750	lb.

DESIGN NO. C-76/.609

$c_1 = (L_B H_{rtr}) - (W H_{cg})$ = 2,781,290 ft. lb.

$c_2 = 2 Y_{rtr} (\Delta T_{Z_{max}})$ = 1,271,400 ft. lb.

$c_3 = 4 T_Z H_{rtr} + c_1$ = 5,329,290 ft. lb.

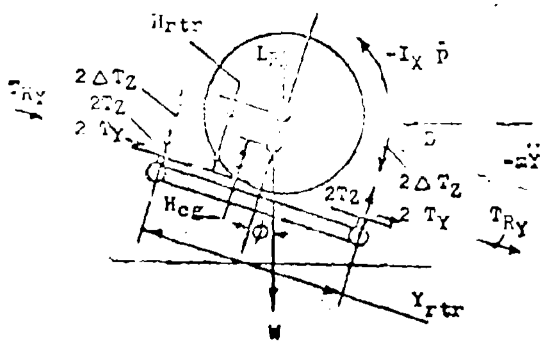
V	= Velocity (sidewards)	kt.	0	15	25	35
D	= Drag	lb.	0	6,048	17,515	32,924
g_1	$= D - 4T_{Y_{max}} - 2T_{R_{Y_{max}}}$	lb.	-12,552	-6,504	4,963	20,372
* $\sin\phi$	$= \frac{g_1}{4T_Z}$	-	0	0	.0954	.3918
g_2	$= D (H_{rtr})$	1,000 ft. lb.	0	296.3	858.2	1,613.3
g_3	$= c_2 - g_2$	10^6 ft. lb.	1.271	0.975	0.413	-0.342
⊕ $\dot{p}$	$= \frac{g_3 - c_1 \sin\phi}{I_X}$	$\frac{\text{rad.}}{\text{sec.}^2}$	.0635	.0487	.0074	-.0715
g_4	$= 4 T_Z (g_3) - c_1 (g_1)$	10^{10} ft. lb^2	10.102	6.8792	0.7681	-7.444
⊕ $\ddot{Y}$	$= \frac{g_4}{m (c_3)}$	$\frac{\text{ft.}}{\text{sec.}^2}$	2.437	1.6590	.1853	-1.796

* If $\sin\phi \leq 0$, make it = 0. Negative $\sin\phi$ indicates that the lateral control force components available are more than sufficient to counteract the lateral drag at a roll angle (ϕ) = 0.

⊕ Negative values indicate that the vehicle cannot be trimmed in roll at this lateral airspeed within the roll control moments available.

ACCELERATION IN LATERAL TRANSLATION AND ROLL

ψ = 90 DEG.



H_{rtr}	=	49.0	ft.
H_{cg}	=	14.8	ft.
$T_{Y_{max}}$	=	759	lb.
$\Delta T_{Z_{max}}$	=	1,071	lb.
m	=	6,606	slugs
I_X	=	15,247,000	slug ft.^{2}
T_Z	=	3,570	lb.
L_B	=	80,900	lb.
W	=	95,180	lb.
Y_{rtr}	=	163	ft.
$T_{R_{Y_{max}}}$	=	750	lb.

DESIGN NO. C-76/.85

$c_1 = (L_B\ H_{rtr}) - (W\ H_{cg})$ = 2,555,436 ft. lb.

$c_2 = 2\ Y_{rtr}\ (\Delta T_{Z_{max}})$ = 349,146 ft. lb.

$c_3 = 4\ T_Z\ H_{rtr} + c_1$ = 3,255,156 ft. lb.

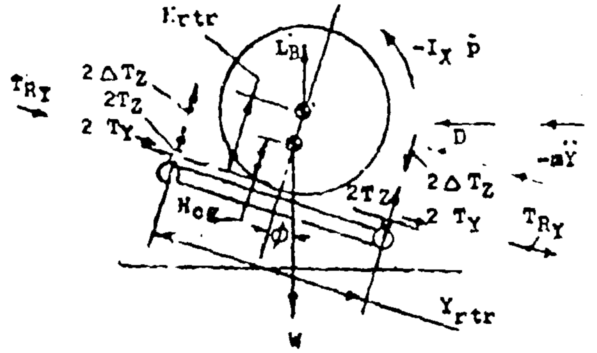
V	= Velocity (sidewards)	kt.	0	15	25	35
D	= Drag	lb.	0	5,956	17,249	32,423
ε_1	$= D - 4T_{Y_{max}} - 2T_{R_{Y_{max}}}$	lb.	-4536	1,420	12,713	27,887
*sin ϕ	$= \frac{\varepsilon_1}{4T_Z}$	-	0	.0994	.8903	*1.953
ε_2	$= D\ (H_{rtr})$	1,000 ft. lb.	0	291.8	845.2	1,588.7
ε_3	$= c_2 - \varepsilon_2$	10^6 ft. lb.	.3491	.0573	-.4961	-1.240
⊚ $\dot{p}$	$= \frac{\varepsilon_3 - c_1 \sin\phi}{I_X}$	rad./sec.^{2}	.0229	-.0129	-.1167	—
ε_4	$= 4\ T_Z\ (\varepsilon_3) - c_1\ (\varepsilon_1)$	10^{10} ft. lb^2	1.6577	-.2810	-3.957	-8.897
⊚ $\ddot{Y}$	$= \frac{\varepsilon_4}{m\ (c_3)}$	ft./sec.^{2}	.7709	-1.3069	-1.840	—

*Sin ϕ cannot exceed 1.0 (ϕ = 90 degrees). At this lateral airspeed the vehicle cannot be trimmed.

⊚Negative values indicate that the vehicle cannot be trimmed in roll at this lateral airspeed within the roll control moments available.

ACCELERATION IN LATERAL TRANSLATION AND ROLL

ψ = 90 DEG.



H_{rtr}	=	37.0	ft.
H_{cg}	=	3.74	ft.
$T_{Y_{max}}$	=	9,608	lb.
$\Delta T_{Z_{max}}$	=	13,560	lb.
m	=	13,328	slugs
I_X	=	37,433,000	slug ft.^{2}
T_Z	=	45,200	lb.
L_B	=	140,800	lb.
W	=	321,600	lb.
Y_{rtr}	=	166	ft.
$T_{R_{Y_{max}}}$	=	18,800	lb.

DESIGN NO. 97-1

$c_1 = (L_B\ H_{rtr}) - (W\ H_{cg}) =$ 4,006,816 ft. lb.

$c_2 = 2\ Y_{rtr}\ (\Delta T_{Z_{max}}) =$ 4,501,920 ft. lb.

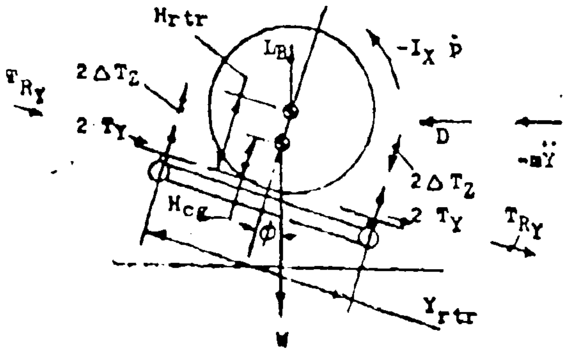
$c_3 = 4\ T_Z\ H_{rtr} + c_1 =$ 10,696,416 ft. lb.

V	= Velocity (Sidewards)	kt.	0	15	25	35
D	= Drag	lb.	0	16,808	46,640	91,520
g_1	$= D - 4T_{Y_{max}} - 2T_{R_{Y_{max}}}$	lb.	-76,032	-59,224	-29,392	+15,488
* $\sin\phi$	$= \frac{g_1}{4T_Z}$	-	0	0	0	.0857
g_2	$= D\ (H_{rtr})$	1,000 ft. lb.	0	621.9	1,726	3,386
g_3	$= c_2 - g_2$	10^6 ft. lb.	4.502	3.880	2.776	1.116
$\dot{p}$	$= \frac{g_3 - c_1 \sin\phi}{I_X}$	rad./sec.^{2}	.1203	.1037	.0741	.0206
g_4	$= 4\ T_Z\ (g_3) - c_1\ (g_1)$	10^{10} ft. lb^2	111.86	93.88	61.97	13.97
$\ddot{Y}$	$= \frac{g_4}{m\ (c_3)}$	ft./sec.^{2}	7.846	6.585	4.347	.980

* If $\sin\phi \lesseqgtr 0$, make it = 0. Negative $\sin\phi$ indicates that the lateral control force components available are more than sufficient to counteract the lateral drag at a roll angle (ϕ) = 0.

ACCELERATION IN LATERAL TRANSLATION AND ROLL

$\psi = 90$ DEG.



H_{rtr}	=	49.0	ft.
H_{cg}	=	14.8	ft.
$T_{Y_{max}}$	=	759	lb.
$\Delta T_{Z_{max}}$	=	3,900	lb.
m	=	6,606	slugs
I_X	=	15,247,000	slug ft.^{2}
T_Z	=	3,570	lb.
L_B	=	80,900	lb.
W	=	95,180	lb.
Y_{rtr}	=	163	ft.
$T_{R_{Y_{max}}}$	=	750	lb.

DESIGN NO. C-76/.85-.609

$c_1 = (L_B\, H_{rtr}) - (W\, H_{cg})$ = [illegible] ft. lb.

$c_2 = 2\, Y_{rtr}\, (\Delta T_{Z_{max}})$ = 1,271,400 ft. lb.

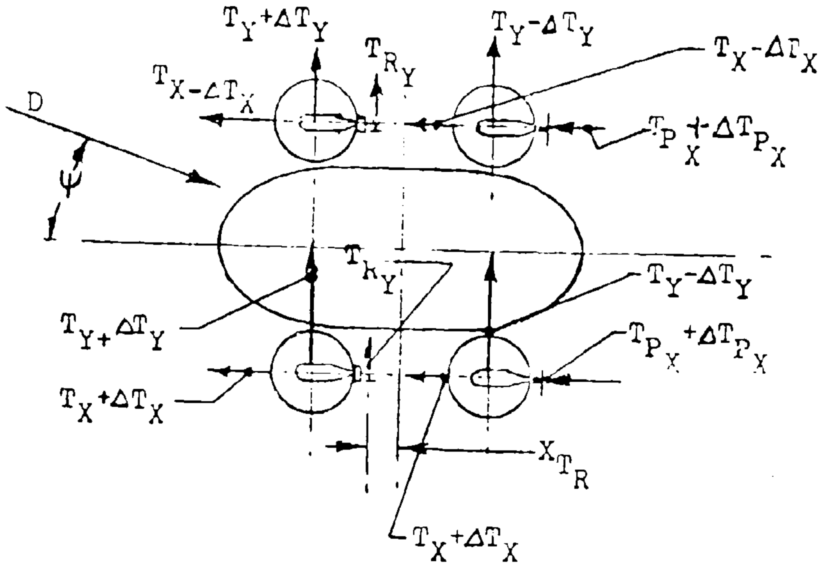
$c_3 = 4\, T_Z\, H_{rtr} + c_1$ = 3,255,156 ft. lb.

V	= Velocity	kt.	0	15	25	35
D	= Drag	lb.	0	5,956	17,249	32,423
g_1	$= D - 4T_{Y_{max}} - 2T_{R_{Y_{max}}}$	lb.	-4536	1,420	12,713	27,887
*sin ϕ	$= \dfrac{g_1}{4T_Z}$	-	0	.0994	.8903	* 1.953
g_2	$= D\,(H_{rtr})$	1,000 ft. lb.	0	291.8	845.2	1,588.7
g_3	$= c_2 - g_2$	10^6 ft. lb.	1.2714	.9796	.4262	-.3173
@ $\dot{p}$	$= \dfrac{g_3 - c_1 \sin\phi}{I_X}$	rad./sec.^{2}	.0834	[illegible]476	-.1213	
g_4	$= 4\,T_Z\,(g_3) - c_1\,(g_1)$	10^{10} ft. lb.^{2}	2.9747	[illegible]60	-2.6400	-7.579
@ $\ddot{Y}$	$= \dfrac{g_4}{m\,(c_3)}$	ft./sec.^{2}	1.3834	[illegible]17	-1.2278	

* Sin ϕ cannot exceed 1.0 (ϕ = 90 degrees). At this lateral airspeed the vehicle cannot be trimmed.

@ Negative values indicate that the vehicle cannot be trimmed in roll at this lateral airspeed within the roll control moments available.

ACCELERATION IN YAW



$\underline{\Sigma X = 0}$

$$4T_X + 2T_{P_X} = D\cos\psi$$

$$2T_X + T_{P_X} = \frac{D\cos\psi}{2}$$

$\underline{\Sigma Y = 0}$

$$2T_{R_Y} + 4T_Y = D\sin\psi$$

Max. Available moment

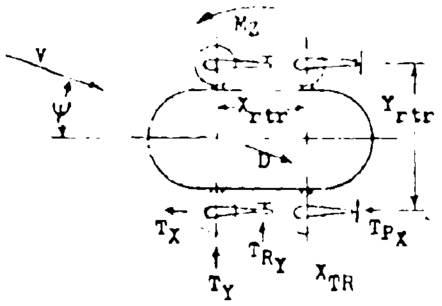
$$M_{Z_{max}} = Y_{rtr}\left[2(T_{X_{max}} - T_X) + (T_{P_{X_{max}}} - T_{P_X})\right] + 2X_{rtr}(T_{Y_{max}} - T_Y) + 2X_{TR}(T_{R_{Y_{max}}} - T_{R_Y})$$

$$= Y_{rtr}\left[(2T_{X_{max}} + T_{P_{X_{max}}}) - (2T_X + T_{P_X})\right] + 2X_{rtr}T_{Y_{max}} + 2X_{TR}T_{R_{Y_{max}}} - (2X_{rtr}T_Y + 2X_{TR}T_{R_Y})$$

$$= Y_{rtr}\left(2T_{X_{max}} + T_{P_{X_{max}}} - \frac{D\cos\psi}{2}\right) + 2X_{rtr}T_{Y_{max}} + 2X_{TR}T_{R_{Y_{max}}} - 2X_{rtr}T_Y - 2X_{TR}T_{R_Y}$$

$$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z}$$

ACCELERATION IN YAW



$T_{X_{max}}$	=	9608	lb.
$T_{Y_{max}}$	=	9608	lb.
X_{rtr}	=	295.25	ft.
Y_{rtr}	=	166	ft.
$T_{RY_{max}}$	=	9,400	lb.
I_Z	=	160,620,000	sl.ft.^{2}
X_{TR}	=	295.25	ft.

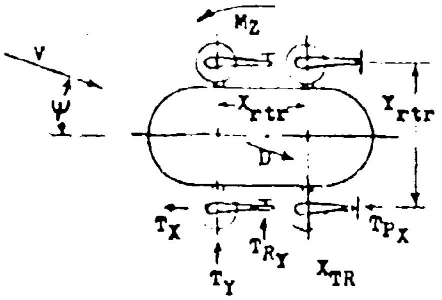
DESIGN NO. 97-1

ψ = 0 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2\left(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}\right) = 14,414,080$ ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	1,121	3,247	6,103
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$g_1 = \frac{D \sin\psi}{4}$	lb.	0	0	0	0
$g_2 = Y_{rtr}\,\frac{D \cos\psi}{2}$	ft.lb.	0	93,043	269,501	506,549
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	0	0	0
$T_{R_{Y_1}}$	lb.	0	0	0	0
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$	ft.lb.	14,414,080	14,321,037	14,144,579	13,907,531
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				
$T_{P_{Y_{max}}}$ (lb)			$\dot{r}$		
0	rad./sec.^{2}	.0898	.0892	.0881	.0866
	rad./sec.^{2}				
	rad./sec.^{2}				
	rad./sec.^{2}				

ACCELERATION IN YAW



$T_{X_{max}}$	=	759	lb.
$T_{Y_{max}}$	=	759	lb.
X_{rtr}	=	76	ft.
Y_{rtr}	=	163	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	17,645,000	sl.ft.^{2}
X_{TR}	=	5	ft.

DESIGN NO. C-76/.85

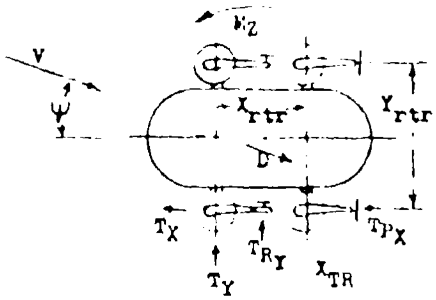
ψ = 0 Degrees

$c_1 = 2Y_{rtr}\, T_{X_{max}} + 2\left(X_{rtr}\, T_{Y_{max}} + X_{TR}\, T_{R_{Y_{max}}}\right) =$ 370,302 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	866	2,402	4,713
Aerc.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$g_1 = \frac{D \sin\psi}{4}$	lb.	0	0	0	0
$g_2 = Y_{rtr} \frac{D \cos\psi}{2}$	ft.lb.	0	70,579	195,763	384,109
If $g_1 \geq T_{Y_{max}},\ T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}},\ T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	0	0	0
$T_{R_{Y_1}}$	lb.	0	0	0	0
$g_3 = c_1 - g_2 - 2X_{rtr}\, T_{Y_1} - 2\, X_{TR}\, T_{R_{Y_1}}$	ft.lb.	370,302	299,723	174,539	-13,807
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\, T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	$\frac{\text{rad.}}{\text{sec.}^2}$				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
428	.030	$\frac{\text{rad.}}{\text{sec.}^2}$	.0249	.0209	.0138	.0032
1,785	.125	$\frac{\text{rad.}}{\text{sec.}^2}$	.0375	.0335	.0264	.0157
7,140	.500	$\frac{\text{rad.}}{\text{sec.}^2}$	.0869	.0829	.0758	.0652
14,280	1.000	$\frac{\text{rad.}}{\text{sec.}^2}$	.1529	.1489	.1418	.1311

ACCELERATION IN YAW



$T_{X_{max}}$	=	2,763	lb.
$T_{Y_{max}}$	=	2,763	lb.
X_{rtr}	=	76	ft.
Y_{rtr}	=	163	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	18,523,000	sl.ft.^{2}
X_{TR}	=	5	ft.

DESIGN NO. C-76/.609

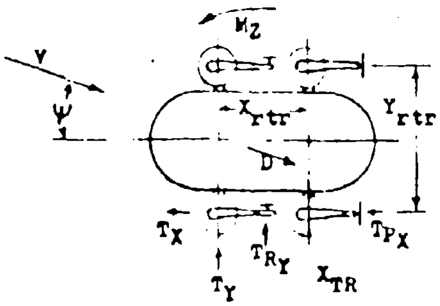
ψ = 0 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2\left(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}\right) = 1{,}328{,}214$ ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	957	2,656	5,212
Aero.Yawing Mom. ($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$g_1 = \dfrac{D \sin\psi}{4}$	lb.	0	0	0	0
$g_2 = Y_{rtr}\,\dfrac{D\cos\psi}{2}$	ft.lb.	0	77,995	216,464	424,778
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	0	0	0
$T_{R_{Y_1}}$	lb.	0	0	0	0
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$	ft.lb.	1,328,214	1,250,219	1,111,750	903,436
$\dot{r} = \dfrac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \dfrac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560	.030	rad./sec.^{2}	.0854	.0812	.0737	.0625
6,500	.125	rad./sec.^{2}	.1289	.1247	.1172	.1060
26,000	.500	rad./sec.^{2}	.3005	.2963	.2888	.2776
52,000	1.000	rad./sec.^{2}	.5293	.5251	.5176	.5064

ACCELERATION IN YAW



$T_{X_{max}}$	= 10,470	lb.
$T_{Y_{max}}$	= 10,470	lb.
X_{rtr}	= 76	ft.
Y_{rtr}	= 163	ft.
$T_{RY_{max}}$	= 750	lb.
I_Z	= 41,236,000	sl.ft.^{2}
X_{TR}	= 5	ft.

DESIGN NO. C-76/.291

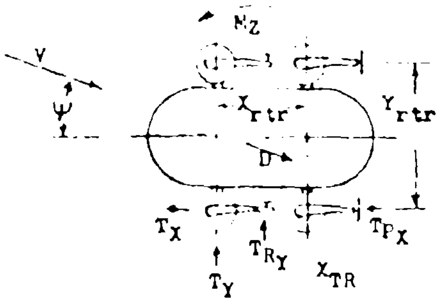
Ψ = 0 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2\left(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}\right) = 5{,}012{,}160$ ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	1,095	3,038	5,961
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$g_1 = \frac{D \sin\Psi}{4}$	lb.	0	0	0	0
$g_2 = Y_{rtr}\,\frac{D \cos\Psi}{2}$	ft.lb.	0	89,242	247,597	485,821
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	0	0	0
$T_{R_{Y_1}}$	lb.	0	0	0	0
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2X_{TR}\,T_{R_{Y_1}}$	ft.lb.	5,012,160	4,922,918	4,764,563	4,526,339
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
5,910	.030	rad./sec.^{2}	.1449	.1427	.1389	.1331
24,600	.125	rad./sec.^{2}	.2188	.2166	.2128	.2070
98,520	.500	rad./sec.^{2}	.5110	.5088	.5039	.4992
197,040	1.000	rad./sec.^{2}	.9004	.8983	.8944	.8886

ACCELERATION IN YAW



$T_{X_{max}}$	=	759	lb.
$T_{Y_{max}}$	=	759	lb.
X_{rtr}	=	130	ft.
Y_{rtr}	=	154	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	21,567,000	sl.ft.^{2}
X_{TR}	=	32	ft.

DESIGN NO. B-130/.85

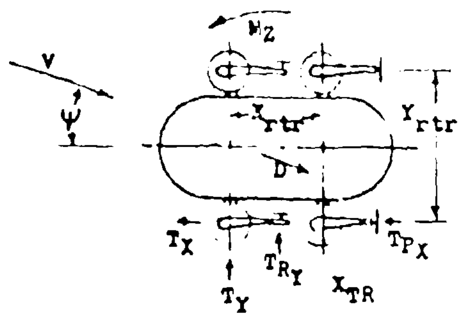
ψ = 0 Degrees

$$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2\left(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}\right) = 479,112 \quad \text{ft.lb.}$$

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	887	2,461	4,830
Aero. Yawing Mom. ($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$\varepsilon_1 = \frac{D \sin\psi}{4}$	lb.	0	0	0	0
$\varepsilon_2 = Y_{rtr}\,\frac{D \cos\psi}{2}$	ft.lb.	0	68,299	189,497	371,910
If $\varepsilon_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(\varepsilon_1 - T_{Y_{max}})$ $\varepsilon_1 \leq T_{Y_{max}}$, $T_{Y_1} = \varepsilon_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	0	0	0
$T_{R_{Y_1}}$	lb.	0	0	0	0
$\varepsilon_3 = c_1 - \varepsilon_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$	ft.lb.	479,112	410,813	289,615	107,202
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{\varepsilon_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	$\frac{\text{rad.}}{\text{sec.}^2}$				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
428	.030	$\frac{\text{rad.}}{\text{sec.}^2}$	.0253	.0221	.0165	.0090
1,785	.125	$\frac{\text{rad.}}{\text{sec.}^2}$	.0350	.0318	.0262	.0177
7,140	.500	$\frac{\text{rad.}}{\text{sec.}^2}$	.0732	.0700	.0644	.0560
14,280	1.000	$\frac{\text{rad.}}{\text{sec.}^2}$	.1242	.1210	.1154	.1069

ACCELERATION IN YAW



$T_{X_{max}}$	=	2,763	lb.
$T_{Y_{max}}$	=	2,763	lb.
X_{rtr}	=	130	ft.
Y_{rtr}	=	154	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	23,298,000	[illegible] t.^{2}
X_{TR}	=	32	ft.

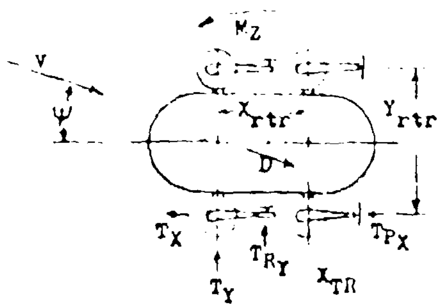
DESIGN NO. B-130/.609

ψ = 0 Degrees

$$c_1 = 2X_{rtr}\,T_{X_{max}} + 2\left(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}\right) = 1{,}617{,}384 \text{ ft.lb.}$$

Velocity (V)		kt.	0	15	25	35
Drag (D)		lb.	0	979	2,716	5,329
Aero.Yawing Mom.($M_{Z_{trim}}$)		ft.lb.	0	0	0	0
$g_1 = \frac{D \sin\psi}{4}$		lb.	0	0	0	0
$g_2 = Y_{rtr}\,\frac{D \cos\psi}{2}$		ft.lb.	0	75,383	209,132	410,333
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$						
T_{Y_1}		lb.	0	0	0	0
$T_{R_{Y_1}}$		lb.	0	0	0	0
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$		ft.lb.	1,617,384	1,542,001	1,408,252	1,207,501
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$		rad./sec.^{2}				
$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560	.030	rad./sec.^{2}	.0797	.0765	.0708	.0621
6,500	.125	rad./sec.^{2}	.1124	.1092	.1034	.0947
26,000	.500	rad./sec.^{2}	.2413	.2380	.2323	.2237
52,000	1.000	rad./sec.^{2}	.4131	.4099	.4042	.3955

ACCELERATION IN YAW



$T_{X_{max}}$ = 10,470 lb.
$T_{Y_{max}}$ = 10,470 lb.
X_{rtr} = 130 ft.
Y_{rtr} = 154 ft.
$T_{RY_{max}}$ = 750 lb.
I_Z = 52,688,000 sl.ft.^{2}
X_{TR} = 32 ft.

DESIGN NO. B-130/.291

Ψ = 0 Degrees

$$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2\left(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}\right) = 5{,}994{,}960 \text{ ft.lb.}$$

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	1,116	3,097	6,078
Aero.Yawing Mom. ($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$g_1 = \frac{D \sin\Psi}{4}$	lb.	0	0	0	0
$g_2 = Y_{rtr}\,\frac{D \cos\Psi}{2}$	ft.lb.	0	85,932	238,469	468,006

If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$

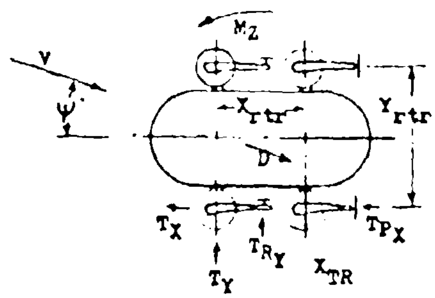
$g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$

T_{Y_1}	lb.	0	0	0	0
$T_{R_{Y_1}}$	lb.	0	0	0	0
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$	ft.lb.	5,994,960	5,709,028	5,756,491	5,526,954

$$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z} \quad \frac{\text{rad.}}{\text{sec.}^2}$$

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
5,910	.030	rad./sec.^{2}	.1311	.1294	.1265	.1722
24,600	.125	rad./sec.^{2}	.1857	.1841	.1812	.1768
98,520	.500	rad./sec.^{2}	.4017	.4001	.3972	.3929
197,040	1.000	rad./sec.^{2}	.6897	.6881	.6852	.6808

ACCELERATION IN YAW



$T_{X_{max}}$	=	759	lb.
$T_{Y_{max}}$	=	759	lb.
X_{rtr}	=	184	ft.
Y_{rtr}	=	137	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	27,007,000	sl.ft.^{2}
X_{TR}	=	59	ft.

DESIGN NO. A-184/.85

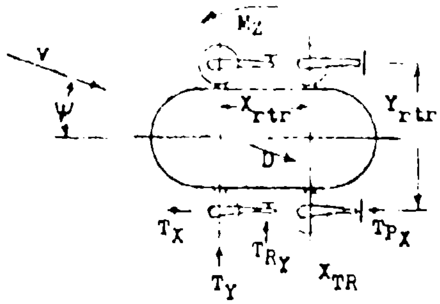
Ψ = 0 Degrees

$c_1 = 2Y_{rtr} T_{X_{max}} + 2\left(X_{rtr} T_{Y_{max}} + X_{TR} T_{R_{Y_{max}}}\right) =$ 575,778 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	898	2,493	4,892
Aero.Yawing Mom. ($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$\varepsilon_1 = \frac{D \sin \Psi}{4}$	lb.	0	0	0	0
$\varepsilon_2 = Y_{rtr} \frac{D \cos \Psi}{2}$	ft.lb.	0	61,513	170,770	335,102
If $\varepsilon_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(\varepsilon_1 - T_{Y_{max}})$ $\varepsilon_1 \leq T_{Y_{max}}$, $T_{Y_1} = \varepsilon_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	0	0	0
$T_{R_{Y_1}}$	lb.	0	0	0	0
$\varepsilon_3 = c_1 - \varepsilon_2 - 2X_{rtr} T_{Y_1} - 2 X_{TR} T_{R_{Y_1}}$	ft.lb.	575,778	514,265	405,008	240,676
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{\varepsilon_3 + Y_{rtr} T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
428	.030	rad./sec.^{2}	.02349	.0212	.0172	.0146
1,785	.125	rad./sec.^{2}	.03037	.0281	.0241	.0215
7,140	.500	rad./sec.^{2}	.0575	.0553	.0512	.0486
14,280	1.000	rad./sec.^{2}	.0938	.0915	.0874	.0848

ACCELERATION IN YAW



$T_{X_{max}}$	=	2,763	lb.
$T_{Y_{max}}$	=	2,763	lb.
X_{rtr}	=	184	ft.
Y_{rtr}	=	137	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	29,940,000	sl.ft.^{2}
X_{TR}	=	59	ft.

DESIGN NO. A-184/.609

Ψ = 0 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2\left(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}\right) = 1{,}862{,}346$ ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	990	2,748	5,391
Aero.Yawing Mom. ($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$\varepsilon_1 = \dfrac{D\sin\Psi}{4}$	lb.	0	0	0	0
$\varepsilon_2 = Y_{rtr}\,\dfrac{D\cos\Psi}{2}$	ft.lb.	0	67,815	188,238	369,283

If $\varepsilon_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(\varepsilon_1 - T_{Y_{max}})$

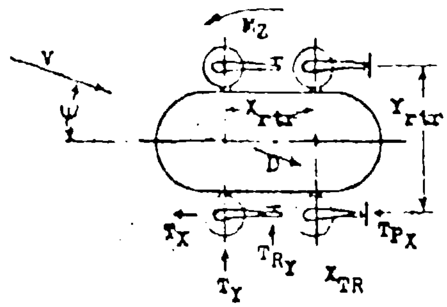
$\varepsilon_1 \leq T_{Y_{max}}$, $T_{Y_1} = \varepsilon_1$ and $T_{R_{Y_1}} = 0$

T_{Y_1}	lb.	0	0	0	0
$T_{R_{Y_1}}$	lb.	0	0	0	0
$\varepsilon_3 = c_1 - \varepsilon_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$	ft.lb.	1,862,346	1,794,531	1,674,108	1,493,063

$$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{\varepsilon_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z} \quad \frac{\text{rad.}}{\text{sec.}^2}$$

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560	.030	rad./sec.^{2}	.0693	.0671	.0631	.0570
6,500	.125	rad./sec.^{2}	.0919	.0897	.0857	.0796
26,000	.500	rad./sec.^{2}	.1812	.1789	.1749	.1688
52,000	1.000	rad./sec.^{2}	.3001	.2979	.2939	.2878

ACCELERATION IN YAW



$T_{X_{max}}$ = 10,470 lb.

$T_{Y_{max}}$ = 10,470 lb.

X_{rtr} = 184 ft.

Y_{rtr} = 137 ft.

$T_{RY_{max}}$ = 750 lb.

I_Z = 69,575,000 sl.ft.^{2}

X_{TR} = 59 ft.

DESIGN NO. A-184/.291

ψ = 0 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2\left(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}\right) = 6,810,240$ ft.lb.

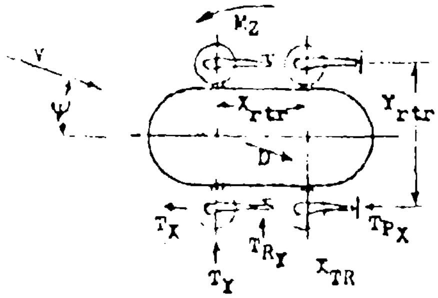
Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	1,128	3,129	6,140
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$g_1 = \frac{D \sin\psi}{4}$	lb.	0	0	0	0
$g_2 = Y_{rtr}\,\frac{D\cos\psi}{2}$	ft.lb.	0	77,268	214,336	420,590

If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$

$g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$

T_{Y_1}		lb.	0	0	0	0
$T_{R_{Y_1}}$		lb.	0	0	0	0
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$		ft.lb.	6,810,240	6,732,972	6,595,904	6,389,650
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$		rad./sec.^{2}				
$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
5,910	.030	rad./sec.^{2}	.1095	.1084	.1064	.1035
24,600	.125	rad./sec.^{2}	.1463	.1452	.1432	.1403
98,520	.500	rad./sec.^{2}	.2919	.2908	.2888	.2858
197,040	1.000	rad./sec.^{2}	.4859	.4848	.4828	.4798

ACCELERATION IN YAW



$T_{X_{max}}$	=	759	lb.
$T_{Y_{max}}$	=	759	lb
X_{rtr}	=	76	ft.
Y_{rtr}	=	163	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	17,645,000	sl.ft.^{2}
X_{TR}	=	5	ft.

DESIGN NO. [illegible]

ψ = 30 Degrees

$c_1 = 2Y_{rtr}\, T_{X_{max}} + 2\left(X_{rtr}\, T_{Y_{max}} + X_{TR}\, T_{R_{Y_{max}}}\right) = 370,302$ ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	2,582	7,166	14,061
Aero.Yawing Mom. ($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,882	1,485,449
$g_1 = \frac{D \sin\psi}{4}$	lb.	0	322	895	1,757
$g_2 = Y_{rtr} \frac{D \cos\psi}{2}$	ft.lb.	0	182,240	505,783	992,440

If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\left(g_1 - T_{Y_{max}}\right)$

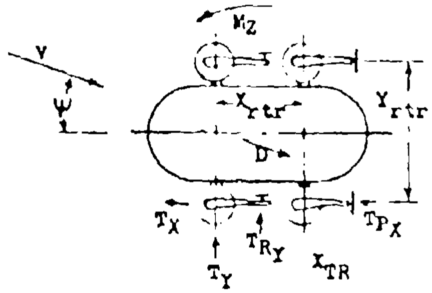
$g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$

T_{Y_1}	lb.	0	322	759	759
$T_{R_{Y_1}}$	lb.	0	0	272	1,996
$g_3 = c_1 - g_2 - 2X_{rtr}\, T_{Y_1} - 2X_{TR}\, T_{R_{Y_1}}$	ft.lb.	370,302	139,118	-253,569	-757,466

$$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\, T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z} \quad \frac{\text{rad.}}{\text{sec.}^2}$$

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
428	.030	rad./sec.^{2}	.0249	-.0036	-.0534	-.1232
1,785	.125	rad./sec.^{2}	.0375	.0089	-.0408	-.1106
7,140	.500	rad./sec.^{2}	.0869	.0584	.0086	-.0612
14,280	1.000	rad./sec.^{2}	.1529	.1243	.0746	.0048

ACCELERATION IN YAW



$T_{X_{max}}$ = 2,763 lb.

$T_{Y_{max}}$ = 2,763 lb.

X_{rtr} = 76 ft.

Y_{rtr} = 163 ft.

$T_{RY_{max}}$ = 750 lb.

I_Z = 18,523,000 sl.ft.^{2}

X_{TR} = 5 ft.

DESIGN NO. C-76/.609

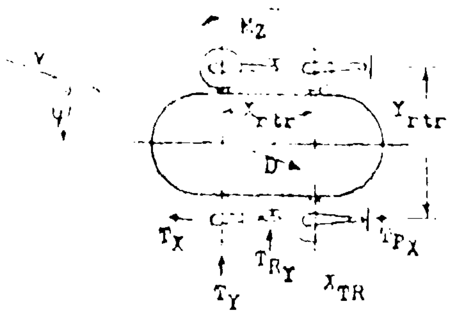
ψ = 30 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2\left(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}\right) = 1,328,214$ ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	2,643	7,335	14,394
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,882	1,485,449
$g_1 = \frac{D \sin\psi}{4}$	lb.	0	330	916	1,799
$g_2 = Y_{rtr}\,\frac{D\cos\psi}{2}$	ft.lb.	0	186,545	517,712	1,015,943
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	330	916	1,799
$T_{R_{Y_1}}$	lb.	0	0	0	0
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$	ft.lb.	1,328,214	1,091,509	671,270	38,823
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	$\frac{\text{rad.}}{\text{sec.}^2}$				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560	.030	$\frac{\text{rad.}}{\text{sec.}^2}$	.0854	.0579	.0091	-.0644
6,500	.125	$\frac{\text{rad.}}{\text{sec.}^2}$	.1289	.1014	.0525	-.0209
26,000	.500	$\frac{\text{rad.}}{\text{sec.}^2}$	.3005	.2730	.2241	.1507
52,000	1.000	$\frac{\text{rad.}}{\text{sec.}^2}$	.5293	.5018	.4529	.3795

ACCELERATION IN YAW



$T_{X_{max}}$ = 10,470 lb.
$T_{Y_{max}}$ = 10,470 lb.
X_{rtr} = 76 ft.
Y_{rtr} = 163 ft.
$T_{RY_{max}}$ = 750 lb.
I_Z = 41,236,000 sl.ft.^{2}
X_{TR} = 5 ft.

[illegible] NO. C-76/.291

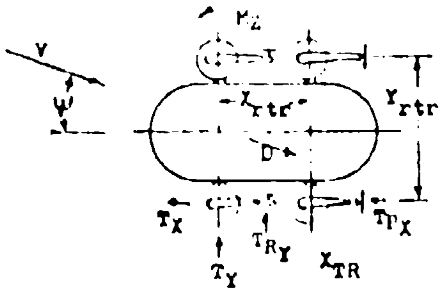
ψ = [illegible] Degrees

$c_1 = 2Y_{rtr} T_{X_{max}} + 2\left(X_{rtr} T_{Y_{max}} + X_{TR} T_{R_{Y_{max}}}\right)$ = 5,012,160 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	2,827	7,544	15,392
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,882	1,485,449
$\varepsilon_1 = \frac{D \sin \psi}{4}$	lb.	0	353	980	1,924
$\varepsilon_2 = Y_{rtr} \frac{D \cos \psi}{2}$	ft.lb.	0	199,53[illegible]	553,637	1,086,383
If $\varepsilon_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(\varepsilon_1 - T_{Y_{max}})$ $\varepsilon_1 \leq T_{Y_{max}}$, $T_{Y_1} = \varepsilon_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	353	980	1,924
$T_{R_{Y_1}}$	lb.	0	0	0	0
$\varepsilon_3 = c_1 - \varepsilon_2 - 2X_{rtr} T_{Y_1} - 2 X_{TR} T_{R_{Y_1}}$	ft.lb.	5,012,160	4,758,972	4,[illegible],563	3,633,329
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{\varepsilon_3 + Y_{rtr} T_{P_{X_r}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
5,910	.030	rad./sec.^{2}	.1449	.1322	.1[illegible]5	.0754
24,600	.125	rad./sec.^{2}	.2158	.2050	.1834	.1493
98,5[illegible]	.500	rad./sec.^{2}	.5110	.4[illegible]2	.4745	.4415
197,040	1.000	rad./sec.^{2}	.9009	.8877	.8650	.8310

ACCELERATION IN YAW



$T_{X_{max}}$	=	750	lb.
$T_{Y_{max}}$	=	759	lb.
X_{rtr}	=	130	ft.
Y_{rtr}	=	154	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	21,567,000	sl.ft.^{2}
X_{TR}	=	32	ft.

DESIGN NO. B-130/.85

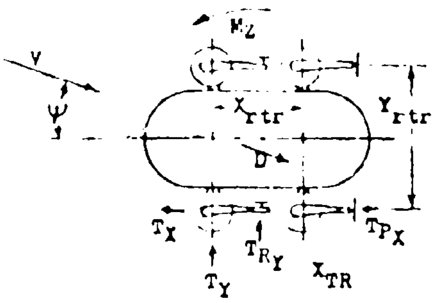
ψ = 30 Degrees

$c_1 = 2Y_{rtr}\, T_{X_{max}} + 2\left(X_{rtr}\, T_{Y_{max}} + X_{TR}\, T_{R_{Y_{max}}}\right) =$ 479,112 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	2,636	7,314	14,352
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,882	1,485,449
$g_1 = \dfrac{D \sin\psi}{4}$	lb.	0	329	914	1,794
$g_2 = Y_{rtr}\,\dfrac{D \cos\psi}{2}$	ft.lb.	0	175,778	487,726	957,048
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	329	759	759
$T_{R_{Y_1}}$	lb.	0	0	310	2,070
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$	ft.lb.	479,112	217,794	-225,794	-807,756
$\dot{r} = \dfrac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \dfrac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
428	.030	rad./sec.^{2}	.0253	.0005	-.0426	-.1033
1,785	.125	rad./sec.^{2}	.0350	.0102	-.0329	-.0936
7,140	.500	rad./sec.^{2}	.0732	.0484	.0054	-.0553
14,280	1.000	rad./sec.^{2}	.1242	.0994	.0564	-.0044

ACCELERATION IN YAW



$T_{X_{max}}$ = 2,763 lb.
$T_{Y_{max}}$ = 2,763 lb.
X_{rtr} = 130 ft.
Y_{rtr} = 154 ft.
$T_{RY_{max}}$ = 750 lb.
I_Z = 23,298,000 sl.ft.^{2}
X_{TR} = 32 ft.

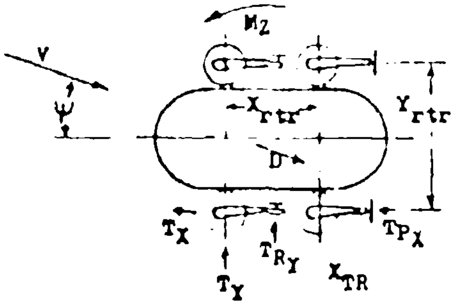
DESIGN NO. B-130/.609

ψ = 30 Degrees

$c_1 = 2Y_{rtr}\, T_{X_{max}} + 2\left(X_{rtr}\, T_{Y_{max}} + X_{TR}\, T_{R_{Y_{max}}}\right) =$ 1,617,384 ft.lb.

Velocity (V)		kt.	0	15	25	35
Drag (D)		lb.	0	2,674	7,420	14,560
Aero.Yawing Mom. ($M_{Z_{trim}}$)		ft.lb.	0	272,838	757,882	1,485,449
$g_1 = \frac{D \sin\psi}{4}$		lb.	0	334	927	1,820
$g_2 = Y_{rtr} \frac{D \cos\psi}{2}$		ft.lb.	0	178,312	494,794	970,918
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$						
T_{Y_1}		lb.	0	334	927	1,820
$T_{R_{Y_1}}$		lb.	0	0	0	0
$g_3 = c_1 - g_2 - 2X_{rtr}\, T_{Y_1} - 2\, X_{TR}\, T_{R_{Y_1}}$		ft.lb.	1,617,384	1,352,232	881,570	173,266
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\, T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$		rad./sec.^{2}				
$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560	.030	rad./sec.^{2}	.0797	.0566	.0156	-.0460
6,500	.125	rad./sec.^{2}	.1124	.0893	.0483	-.0134
26,000	.500	rad./sec.^{2}	.2413	.2182	.1772	.1155
52,000	1.000	rad./sec.^{2}	.4131	.3901	.3490	.2874

ACCELERATION IN YAW



$T_{X_{max}}$ = 10,470 lb.

$T_{Y_{max}}$ = 10,470 lb.

X_{rtr} = 130 ft.

Y_{rtr} = 154 ft.

$T_{RY_{max}}$ = 750 lb.

I_Z = 52,688,000 sl.ft.^{2}

X_{TR} = 32 ft.

DESIGN NO. B-130/.291

ψ = 30 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2\left(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}\right) = 5{,}994{,}960$ ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	2,918	8,098	15,891
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,882	1,485,449
$g_1 = \frac{D \sin\psi}{4}$	lb.	0	364	1,012	1,986
$g_2 = Y_{rtr}\,\frac{D\cos\psi}{2}$	ft.lb.	0	194,583	540,006	1,059,674

If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$

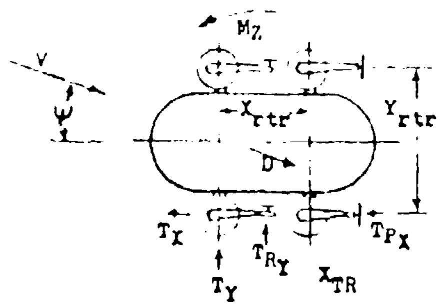
$g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$

T_{Y_1}	lb.	0	364	1,012	1,986
$T_{R_{Y_1}}$	lb.	0	0	0	0
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$	ft.lb.	5,994,960	5,706,517	5,191,834	4,418,926

$$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z} \quad \frac{\text{rad.}}{\text{sec.}^2}$$

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
5,910	.030	rad./sec.^{2}	.1311	.1204	.1014	.0730
24,600	.125	rad./sec.^{2}	.1857	.1750	.1560	.1276
98,520	.500	rad./sec.^{2}	.4017	.3911	.3721	.3436
197,040	1.000	rad./sec.^{2}	.6897	.6791	.6601	.6316

ACCELERATION IN YAW



$T_{X_{max}}$	=	759	lb.
$T_{Y_{max}}$	=	759	lb.
X_{rtr}	=	184	ft.
Y_{rtr}	=	137	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	27,007,000	sl.ft.^{2}
X_{TR}	=	59	ft.

DESIGN NO. A-184/.85

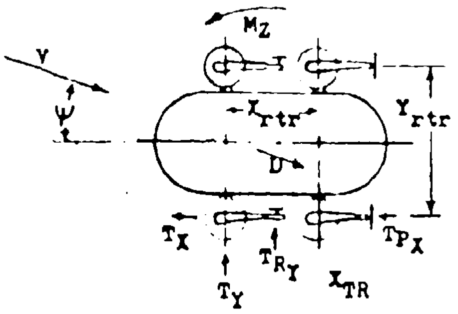
ψ = 30 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2\left(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}\right) =$ 575,778 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	2,705	7,505	14,726
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,882	1,485,449
$\varepsilon_1 = \frac{D \sin\psi}{4}$	lb.	0	338	938	1,840
$\varepsilon_2 = Y_{rtr}\,\frac{D\cos\psi}{2}$	ft.lb.	0	160,468	445,217	873,586
If $\varepsilon_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(\varepsilon_1 - T_{Y_{max}})$ $\varepsilon_1 \leq T_{Y_{max}}$, $T_{Y_1} = \varepsilon_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	338	759	759
$T_{R_{Y_1}}$	lb.	0	0	358	2,162
$\varepsilon_3 = c_1 - \varepsilon_2 - 2X_{rtr}\,T_{Y_1} - 2X_{TR}\,T_{R_{Y_1}}$	ft.lb.	575,778	290,926	-190,995	-832,236
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{\varepsilon_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
428	.030	rad./sec.^{2}	.0235	.0028	-.0330	-.0836
1,785	.125	rad./sec.^{2}	.0304	.0097	-.0261	-.0768
7,140	.500	rad./sec.^{2}	.0575	.0369	.0011	-.0496
14,280	1.000	rad./sec.^{2}	.0938	.0731	.0373	-.0134

ACCELERATION IN YAW



$T_{X_{max}}$ = 2,763 lb.

$T_{Y_{max}}$ = 2,763 lb.

X_{rtr} = 184 ft.

Y_{rtr} = 137 ft.

$T_{RY_{max}}$ = 750 lb.

I_Z = 29,940,000 sl.ft.^{2}

X_{TR} = 59 ft.

DESIGN NO. A-184/.609

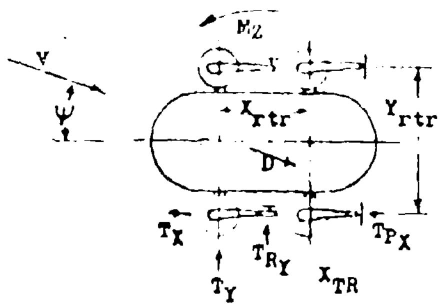
ψ = 30 Degrees

$c_1 = 2Y_{rtr}\, T_{X_{max}} + 2\left(X_{rtr}\, T_{Y_{max}} + X_{TR}\, T_{R_{Y_{max}}}\right) = 1,862,346$ ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	2,735	7,590	14,893
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,882	1,485,449
$g_1 = \frac{D \sin\psi}{4}$	lb.	0	341	948	1,861
$g_2 = Y_{rtr} \frac{D \cos\psi}{2}$	ft.lb.	0	162,247	450,259	883,493
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	341	948	1,861
$T_{R_{Y_1}}$	lb.	0	0	0	0
$g_3 = c_1 - g_2 - 2X_{rtr}\, T_{Y_1} - 2\, X_{TR}\, T_{R_{Y_1}}$	ft.lb.	1,862,346	1,574,243	1,063,223	294,005
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\, T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560	.030	rad./sec.^{2}	.0693	.0506	.0173	-.0326
6,500	.125	rad./sec.^{2}	.0919	.0732	.0399	-.0101
26,000	.500	rad./sec.^{2}	.1812	.1624	.1292	.0792
52,000	1.000	rad./sec.^{2}	.3001	.2814	.2481	.1981

ACCELERATION IN YAW



$T_{X_{max}}$	=	10,470	lb.
$T_{Y_{max}}$	=	10,470	lb.
X_{rtr}	=	184	ft.
Y_{rtr}	=	137	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	69,575,000	sl.ft.^{2}
X_{TR}	=	59	ft.

DESIGN NO. A-184/.291

ψ = 30 Degrees

$$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2\left(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}\right) = 6{,}810{,}240 \text{ ft.lb.}$$

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	2,980	8,268	16,224
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,882	1,485,449
$g_1 = \frac{D \sin\psi}{4}$	lb.	0	372	1,033	2,028
$g_2 = Y_{rtr}\,\frac{D\cos\psi}{2}$	ft.lb.	0	176,781	490,480	962,452

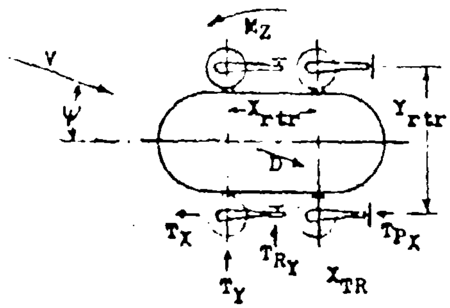
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$

$g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$

T_{Y_1}	lb.	0	372	1,033	2,028
$T_{R_{Y_1}}$	lb.	0	0	0	0
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$	ft.lb.	6,810,240	6,496,563	5,939,616	5,101,484
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{R_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
5,910	.030	rad./sec.^{2}	.1095	.1011	.0861	.0636
24,600	.125	rad./sec.^{2}	.1463	.1379	.1229	.1004
98,520	.500	rad./sec.^{2}	.2919	.2834	.2685	.2460
197,040	1.000	rad./sec.^{2}	.4859	.4774	.4625	.4400

ACCELERATION IN YAW



$T_{X_{max}}$	=	759	lb.
$T_{Y_{max}}$	=	759	lb.
X_{rtr}	=	76	ft.
Y_{rtr}	=	163	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	17,645,000	sl.ft.^{2}
X_{TR}	=	5	ft.

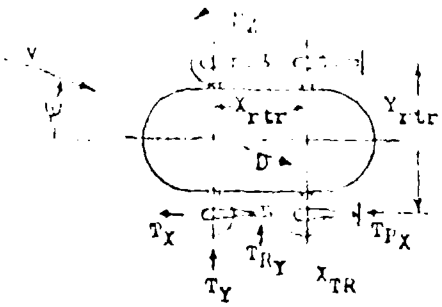
DESIGN NO. C-76/.85

ψ = 60 Degrees

$c_1 = 2Y_{rtr} T_{X_{max}} + 2\left(X_{rtr} T_{Y_{max}} + X_{TR} T_{R_{Y_{max}}}\right) =$ 370,302 ft.lb.

Velocity (V)		kt.	0	15	25	35
Drag (D)		lb.	0	5,107	14,172	27,810
Aero.Yawing Mom.($M_{Z_{trim}}$)		ft.lb.	0	272,838	757,882	1,485,449
$g_1 = \dfrac{D \sin\psi}{4}$		lb.	0	1,105	3,068	6,021
$g_2 = Y_{rtr} \dfrac{D \cos\psi}{2}$		ft.lb.	0	208,110	577,509	1,133,257
If $g_1 \geq T_{Y_{max}},\ T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}},\ T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$						
T_{Y_1}		lb.	0	759	759	759
$T_{R_{Y_1}}$		lb.	0	692	4,618	10,524
$g_3 = c_1 - g_2 - 2X_{rtr} T_{Y_1} - 2X_{TR} T_{R_{Y_1}}$		ft.lb.	370,302	39,604	-368,755	-983,563
$\dot{r} = \dfrac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \dfrac{g_3 + Y_{rtr} T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$		$\dfrac{\text{rad.}}{\text{sec.}^2}$				
$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
428	.030	$\dfrac{\text{rad.}}{\text{sec.}^2}$	.0249	-.0092	-.0599	-.1360
1,785	.125	$\dfrac{\text{rad.}}{\text{sec.}^2}$	.0375	.0033	-.0474	-.1234
7,140	.500	$\dfrac{\text{rad.}}{\text{sec.}^2}$	.0869	.0528	.0021	-.0740
14,280	1.000	$\dfrac{\text{rad.}}{\text{sec.}^2}$	.1529	.1187	.0681	-.0080

ACCELERATION IN YAW



$T_{X_{max}}$	=	[illegible]	lb.
$T_{Y_{max}}$	=	[illegible]	lb.
X_{rtr}	=	25	ft.
Y_{rtr}	=	[illegible]	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	18,593,000	sl.ft.^{2}
X_{TR}	=	5	ft.

DESIGN NO. C-76[illegible]

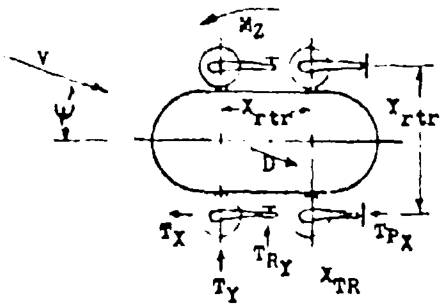
Ψ = 60 Degrees

$c_1 = 2Y_{rtr} T_{X_{max}} + 2\left(X_{rtr} T_{Y_{max}} + X_{TR} T_{R_{Y_{max}}}\right) =$ 1,328,214 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	5,172	14,352	23,163
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,882	1,485,449
$\varepsilon_1 = \frac{D \sin\Psi}{4}$	lb.	0	1.11	3,107	6,097
$\varepsilon_2 = Y_{rtr} \frac{D \cos\Psi}{2}$	ft.lb.	0	210,759	584,844	1,147,642
If $\varepsilon_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(\varepsilon_1 - T_{Y_{max}})$ $\varepsilon_1 \leq T_{Y_{max}}$, $T_{Y_1} = \varepsilon_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	1.119	2,763	2,763
$T_{R_{Y_1}}$	lb.	0	0	688	6,668
$\varepsilon_3 = c_1 - \varepsilon_2 - 2X_{rtr} T_{Y_1} - 2X_{TR} T_{R_{Y_1}}$	ft.lb.	1,328,214	947,367	316,514	-306,084
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{\varepsilon_3 + Y_{rtr} T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	$\frac{\text{rad.}}{\text{sec.}^2}$				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}} / T_{Z_{total}}$		$\dot{r}$			
1,560	.030	$\frac{\text{rad.}}{\text{sec.}^2}$	.0854	.0501	-.0101	-.0830
6,500	.125	$\frac{\text{rad.}}{\text{sec.}^2}$	.1289	.0936	.0334	-.0395
26,000	.500	$\frac{\text{rad.}}{\text{sec.}^2}$	.3005	.2652	.2050	.1321
52,000	1.000	$\frac{\text{rad.}}{\text{sec.}^2}$	.5293	.4940	.4338	.3609

ACCELERATION IN YAW



$T_{X_{max}}$	=	10,470	lb.
$T_{Y_{max}}$	=	10,470	lb.
X_{rtr}	=	76	ft.
Y_{rtr}	=	163	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	41,236,000	sl.ft.^{2}
X_{TR}	=	5	ft.

DESIGN NO. C-76/.291

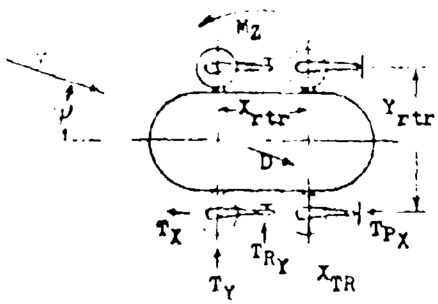
ψ = 60 Degrees

$$c_1 = 2Y_{rtr}\, T_{X_{max}} + 2\left(X_{rtr}\, T_{Y_{max}} + X_{TR}\, T_{R_{Y_{max}}}\right) = 5{,}012{,}160 \text{ ft.lb.}$$

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	5,570	15,455	30,326
Aero.Yawing Mom. ($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,882	1,485,449
$g_1 = \frac{D \sin\psi}{4}$	lb.	0	1,205	3,346	6,565
$g_2 = Y_{rtr} \frac{D \cos\psi}{2}$	ft.lb.	0	226,977	629,791	1,235,784
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(g_1 - T_{Y_{max}})$; $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	1,205	3,346	6,565
$T_{R_{Y_1}}$	lb.	0	0	0	0
$g_3 = c_1 - g_2 - 2X_{rtr} T_{Y_1} - 2X_{TR} T_{R_{Y_1}}$	ft.lb.	5,012,160	4,602,023	3,873,777	2,778,496
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr} T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
5,910	.030	rad./sec.^{2}	.1449	.1283	.0989	.0549
24,600	.125	rad./sec.^{2}	.2188	.2022	.1728	.1286
98,520	.500	rad./sec.^{2}	.5110	.4944	.4650	.4208
197,040	1.000	rad./sec.^{2}	.9004	.8838	.8544	.8102

ACCELERATION IN YAW



[illegible]ax	=	759	lb.
$T_{Y_{max}}$	=	759	lb.
X_{rtr}	=	130	ft.
Y_{rtr}	=	154	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	21,[illegible],000	sl.ft.^{2}
X_{TR}	=	32	ft.

DESIGN NO. B-130/.85

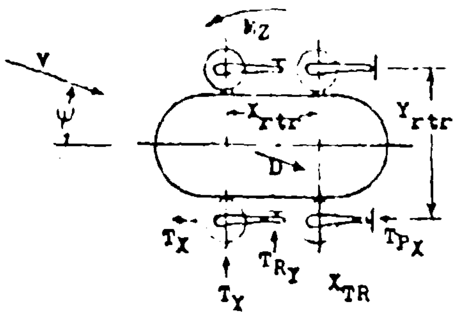
ψ = 60 Degrees

$$c_1 = 2Y_{rtr}\, T_{X_{max}} + 2\left(X_{rtr}\, T_{Y_{max}} + X_{TR}\, T_{R_{Y_{max}}}\right) = 479{,}112 \text{ ft.lb.}$$

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	5,249	14,564	28,579
Aero.Yawing Mom. ($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,882	1,485,449
$g_1 = \dfrac{D \sin\psi}{4}$	lb.	0	1,136	3,153	6,187
$g_2 = Y_{rtr}\dfrac{D\cos\psi}{2}$	ft.lb.	0	202,086	560,714	1,100,291
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$; $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	759	759	759
$T_{R_{Y_1}}$	lb.	0	754	4,788	10,856
$g_3 = c_1 - g_2 - 2X_{rtr}\, T_{Y_1} - 2\, X_{TR}\, T_{R_{Y_1}}$	ft.lb.	479,112	31,430	-226,746	-615,098
$\dot{r} = \dfrac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \dfrac{g_3 + Y_{rtr}\, T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
428	.030	rad./sec.^{2}	.0253	-.0091	-.0426	-.0943
1,785	.125	rad./sec.^{2}	.0350	.0016	-.0329	-.0847
7,140	.500	rad./sec.^{2}	.0732	.0398	.0053	-.0464
14,280	1.000	rad./sec.^{2}	.1242	.0908	.0563	.0646

ACCELERATION IN YAW



$T_{X_{max}}$ = 2,763 lb.

$T_{Y_{max}}$ = 2,763 lb.

X_{rtr} = 13[illegible] ft.

Y_{rtr} = 154 ft.

$T_{RY_{max}}$ = 750 lb.

I_Z = 23,298,000 sl.ft.^{2}

X_{TR} = 32 ft.

[illegible] NO. P-1[illegible]/,600

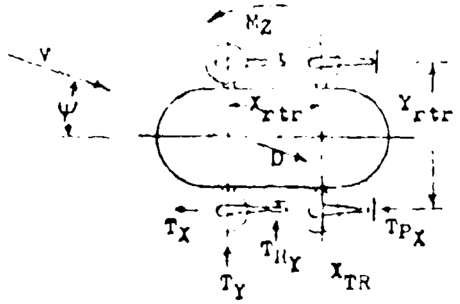
ψ = 60 Degrees

$$c_1 = 2Y_{rtr}\, T_{X_{max}} + 2\left(X_{rtr}\, T_{Y_{max}} + X_{TR}\, T_{R_{Y_{max}}}\right) = 1,617,384 \text{ ft.lb.}$$

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	5,295	14,692	28,829
Aero.Yawing Mom. ($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,882	1,485,449
$g_1 = \frac{D \sin\psi}{4}$	lb.	0	1,146	3,180	6,241
$g_2 = Y_{rtr} \frac{D \cos\psi}{2}$	ft.lb.	0	203,857	565,642	1,109,916
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	1,146	2,763	2,763
$T_{R_{Y_1}}$	lb.	0	0	834	6,956
$g_3 = c_1 - g_2 - 2X_{rtr} T_{Y_1} - 2X_{TR} T_{R_{Y_1}}$	ft.lb.	1,617,384	1,319,424	279,986	-656,096
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr} T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{R_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560	.030	rad./sec.^{2}	.0797	.0552	-.0102	-.0816
6,500	.125	rad./sec.^{2}	.1124	.0879	.0224	.0490
26,000	.500	rad./sec.^{2}	.2413	.2168	.1513	.0799
52,000	1,000	rad./sec.^{2}	.4131	.3886	.3232	.2518

ACCELERATION IN YAW



$T_{X_{max}}$ = 10,470 lb.

$T_{Y_{max}}$ = 10,470 lb.

X_{rtr} = 130 ft.

Y_{rtr} = 154 ft.

$T_{RY_{max}}$ = 750 lb.

I_Z = 52,683,000 sl.ft.^{2}

X_{TR} = 32 ft.

DESIGN NO. B-130/.291

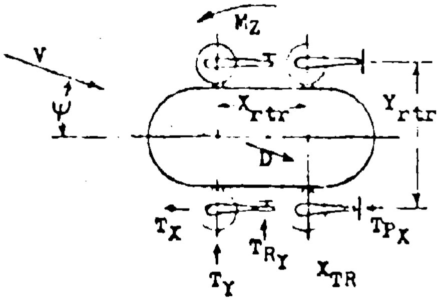
Ψ = 60 Degrees

$c_1 = 2Y_{rtr}\, T_{X_{max}} + 2\left(X_{rtr}\, T_{Y_{max}} + X_{TR}\, T_{R_{Y_{max}}}\right) = 5{,}994{,}960$ ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	5,715	15,858	31,117
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,832	1,485,449
$\varepsilon_1 = \frac{D \sin\Psi}{4}$	lb.	0	1,237	3,433	6,737
$\varepsilon_2 = Y_{rtr} \frac{D \cos\Psi}{2}$	ft.lb.	0	220,027	610,533	1,198,004
If $\varepsilon_1 \geq T_{Y_{max}},\ T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(\varepsilon_1 - T_{Y_{max}})$ $\varepsilon_1 \leq T_{Y_{max}},\ T_{Y_1} = \varepsilon_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	1,237	3,433	6,737
$T_{R_{Y_1}}$	lb.	0	0	0	0
$\varepsilon_3 = c_1 - \varepsilon_2 - 2X_{rtr}\, T_{Y_1} - 2\, X_{TR}\, T_{R_{Y_1}}$	ft.lb.	5,994,960	5,453,333	4,491,847	[illegible] 045,336
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{\varepsilon_3 + Y_{rtr}\, T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	$\frac{\text{rad.}}{\text{sec.}^2}$				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
5,910	.030	$\frac{\text{rad.}}{\text{sec.}^2}$	.1311	.1116	.0881	.0469
24,600	.125	$\frac{\text{rad.}}{\text{sec.}^2}$	.1857	.1702	.1428	.1[illegible]5
98,520	.500	$\frac{\text{rad.}}{\text{sec.}^2}$	.4017	.3863	.3588	.3176
197,040	1.000	$\frac{\text{rad.}}{\text{sec.}^2}$	.6897	.6742	.6468	.6055

ACCELERATION IN YAW



$T_{X_{max}}$	=	759	lb.
$T_{Y_{max}}$	=	75[illegible]	lb.
X_{rtr}	=	18[illegible]	ft.
Y_{rtr}	=	137	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	27,007,000	sl.ft.^{2}
X_{TR}	=	59	ft.

DESIGN NO. A-184/.85

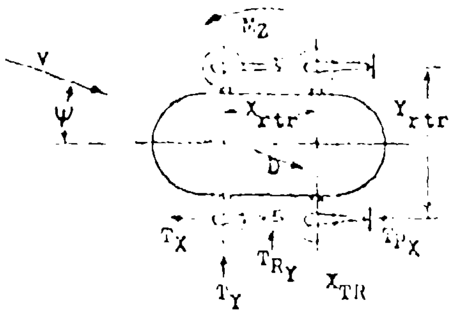
Ψ = 60 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2\left(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}\right) = 575,778$ ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	5,447	15,116	29,661
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,882	1,485,449
$g_1 = \dfrac{D \sin\Psi}{4}$	lb.	0	1,179	3,272	6,421
$g_2 = Y_{rtr}\,\dfrac{D \cos\Psi}{2}$	ft.lb.	0	186,559	517,723	1,015,889
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	759	759	759
$T_{R_{Y_1}}$	lb.	0	840	5,026	11,324
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$	ft.lb.	575,778	10,787	-814,325	-2,055,65[illegible]
$\dot{r} = \dfrac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \dfrac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
428	.030	rad./sec.^{2}	.0235	-.0075	.0560	-.1289
1,785	.125	rad./sec.^{2}	.0304	-.0006	-.0492	-.1221
7,140	.500	rad./sec.^{2}	.0575	.0265	-.0220	-.0949
14,280	1.000	rad./sec.^{2}	.0938	.0627	.0142	-.0587

ACCELERATION IN YAW



$T_{X_{max}}$	=	2,763	lb.
$T_{Y_{max}}$	=	2,763	lb.
X_{rtr}	=	184	ft.
Y_{rtr}	=	137	ft.
$T_{RY_{max}}$	=	759	lb.
I_Z	=	29,940,000	sl.ft.^{2}
X_{TR}	=	59	ft.

DESIGN NO. A-1[illegible]/.609

ψ = 60 Degrees

$$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2\left(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}\right) = 1,862,346 \text{ ft.lb.}$$

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	5,524	15,328	30,077
Aero.Yawing Mom. ($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,882	1,485,449
$\varepsilon_1 = \dfrac{D \sin\psi}{4}$	lb.	0	1,195	3,318	6,511
$\varepsilon_2 = Y_{rtr}\dfrac{D\cos\psi}{2}$	ft.lb.	0	189,197	524,984	1,028,032

If $\varepsilon_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(\varepsilon_1 - T_{Y_{max}})$

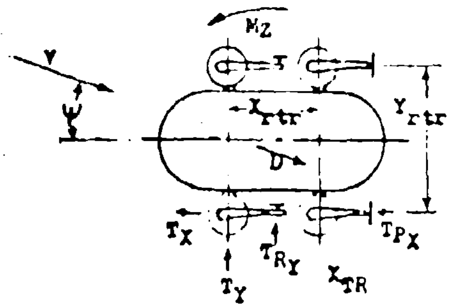
$\varepsilon_1 \leq T_{Y_{max}}$, $T_{Y_1} = \varepsilon_1$ and $T_{R_{Y_1}} = 0$

		0	15	25	35
T_{Y_1}	lb.	0	1,195	2,763	2,763
$T_{R_{Y_1}}$	lb.	0	0	1,110	7,496
$\varepsilon_3 = c_1 - \varepsilon_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$	ft.lb.	1,862,346	1,233,389	185,598	-1,067,048

$$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{\varepsilon_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z} \quad \frac{\text{rad.}}{\text{sec.}^2}$$

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560	.030	rad./sec.^{2}	.0693	.[illegible]392	-.0120	-.0781
6,500	.125	rad./sec.^{2}	.0919	.0618	.0106	-.0555
26,000	.500	rad./sec.^{2}	.1612	.1511	.0999	.0337
52,000	1.000	rad./sec.^{2}	.3001	.2700	.2188	.1527

ACCELERATION IN YAW



$T_{X_{max}}$	=	10,470	lb.
$T_{Y_{max}}$	=	10,470	lb.
X_{rtr}	=	184	ft.
Y_{rtr}	=	137	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	69,575,000	sl.ft.^{2}
X_{TR}	=	59	ft.

DESIGN NO. A-184/.291

Ψ = 60 Degrees

$$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2\left(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}\right) = 6,810,240 \text{ ft.lb.}$$

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	5,890	16,345	32,074
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,882	1,485,449
$g_1 = \frac{D \sin\Psi}{4}$	lb.	0	1,275	3,538	6,944
$g_2 = Y_{rtr}\,\frac{D\cos\Psi}{2}$	ft.lb.	0	201,732	559,816	1,098,534

If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$

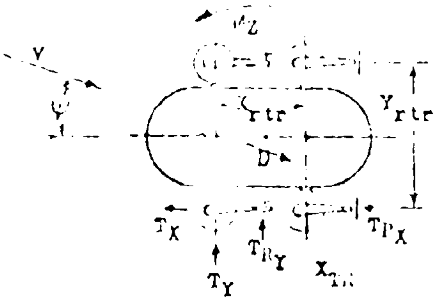
$g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$

T_{Y_1}	lb.	0	1,275	3,538	6,944
$T_{R_{Y_1}}$	lb.	0	0	0	0
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$	ft.lb.	6,810,240	6,139,308	4,948,440	3,156,314

$$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z} \quad \frac{\text{rad.}}{\text{sec.}^2}$$

$T_{R_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
5,910	.030	rad./sec.^{2}	.1095	.0960	.0719	.0357
24,600	.125	rad./sec.^{2}	.1463	.1328	.1087	.0725
98,520	.500	rad./sec.^{2}	.2919	.2783	.2542	.2180
197,040	1.000	rad./sec.^{2}	.4859	.4723	.4482	.4120

A[illegible]ERATION IN YAW



$T_{X_{max}}$ = 759 lb.

$T_{Y_{max}}$ = 759 lb.

X_{rtr} = 76 ft.

Y_{rtr} = 163 ft.

$T_{RY_{max}}$ = 750 lb.

I_Z = 17,645,000 sl.ft.^{2}

X_{TR} = 5 ft.

[illegible] NO. [illegible]

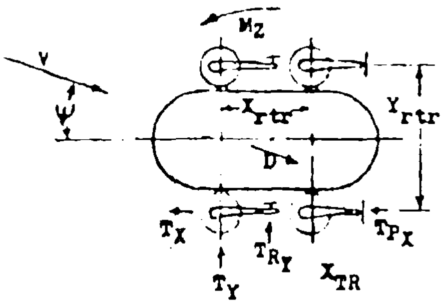
ψ = [illegible]

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2\left(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}\right) =$ [illegible] ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	5,[illegible]	16,532	32,440
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$\varepsilon_1 = \frac{D \sin\psi}{4}$	lb.	0	1,439	4,133	8,110
$\varepsilon_2 = Y_{rtr}\,\frac{D\cos\psi}{2}$	ft.lb.	0	0	0	0
If $\varepsilon_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(\varepsilon_1 - T_{Y_{max}})$; $\varepsilon_1 \leq T_{Y_{max}}$, $T_{Y_1} = \varepsilon_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	759	759	759
$T_{R_{Y_1}}$	lb.	0	1,460	6,748	14,702
$\varepsilon_3 = c_1 - \varepsilon_2 - 2X_{rtr}\,T_{Y_1} - 2X_{TR}\,T_{R_{Y_1}}$	ft.lb.	370,302	240,334	187,454	107,914
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{\varepsilon_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{[illegible]}}$		$\dot{r}$			
[illegible]	.0[illegible]	rad./sec.^{2}	.[illegible]249	.0176	.01[illegible]	.0101
1,7[illegible]	.1[illegible]	rad./sec.^{2}	.0325	.[illegible]	.[illegible]	.[illegible]
7,1[illegible]	.50[illegible]	rad./sec.^{2}	.0[illegible]	.07[illegible]	.0[illegible]	.[illegible]
14,2[illegible]	1.000	rad./sec.^{2}	.1[illegible]	.145[illegible]	.[illegible]	.1[illegible]

ACCELERATION IN YAW



$T_{X_{max}}$	=	2,763	lb.
$T_{Y_{max}}$	=	2,763	lb.
X_{rtr}	=	76	ft.
Y_{rtr}	=	163	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	18,523,000	sl.ft.^{2}
X_{TR}	=		ft.

DESIGN NO. C-76/.609

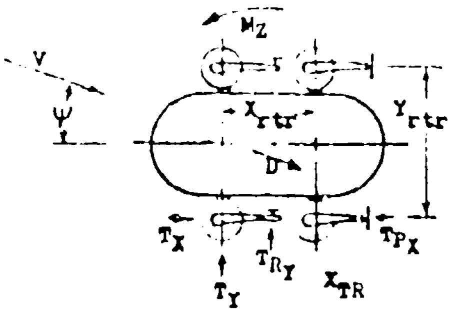
ψ = 90 Degrees

$c_1 = 2Y_{rtr}\, T_{X_{max}} + 2\left(X_{rtr}\, T_{Y_{max}} + X_{TR}\, T_{R_{Y_{max}}}\right) = 1{,}328{,}214$ ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	6,049	16,786	32,939
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$g_1 = \frac{D \sin\psi}{4}$	lb.	0	1,512	4,196	8,234
$g_2 = Y_{rtr} \frac{D \cos\psi}{2}$	ft.lb.	0	0	0	0
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	1,512	2,763	2,763
$T_{R_{Y_1}}$	lb.	0	0	2,866	10,942
$g_3 = c_1 - g_2 - 2X_{rtr} T_{Y_1} - 2X_{TR} T_{R_{Y_1}}$	ft.lb.	1,328,214	1,098,390	879,578	798,818
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr} T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560	.030	rad./sec.^{2}	.0854	.0730	.0612	.0569
6,500	.125	rad./sec.^{2}	.1289	.1165	.1047	.1003
26,000	.500	rad./sec.^{2}	.3005	.2831	.2763	.2719
52,000		rad./sec.^{2}	.529	.5169	.5051	.5007

ACCELERATION IN YAW



$T_{X_{max}}$	=	10,470	lb.
$T_{Y_{max}}$	=	10,470	lb.
X_{rtr}	=	76	ft.
Y_{rtr}	=	163	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	41,236,000	sl.ft.^{2}
X_{TR}	=	5	ft.

DESIGN NO. C-76/.291

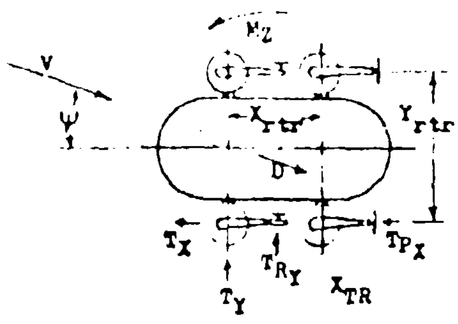
Ψ = 90 Degrees

$c_1 = 2Y_{rtr}\, T_{X_{max}} + 2\left(X_{rtr}\, T_{Y_{max}} + X_{TR}\, T_{R_{Y_{max}}}\right) =$ 5,012,160 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	6,489	18,007	35,335
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$g_1 = \frac{D \sin \Psi}{4}$	lb.	0	1,622	4,501	8,833
$g_2 = Y_{rtr} \frac{D \cos \Psi}{2}$	ft.lb.	0	0	0	0
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	1,622	4,501	8,833
$T_{R_{Y_1}}$	lb.	0	0	0	0
$g_3 = c_1 - g_2 - 2X_{rtr}\, T_{Y_1} - 2\, X_{TR}\, T_{R_{Y_1}}$	ft.lb.	5,012,160	4,765,616	4,328,008	3,669,544
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\, T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	$\frac{\text{rad.}}{\text{sec.}^2}$				

$T_{P_{X_{max}}}$ (lb)	$T_{P_X}/T_{Z_{total}}$		$\dot{r}$			
5,910	.030	$\frac{\text{rad.}}{\text{sec.}^2}$	.1449	.1389	.1283	.1124
24,600	.125	$\frac{\text{rad.}}{\text{sec}^2}$	[illegible]	.2128	[illegible]	.1862
98,520	.500	$\frac{\text{rad}}{\text{sec}^2}$	.5110	[illegible]	[illegible]	[illegible]
197,040	1.000	$\frac{\text{rad}}{\text{sec}^2}$	.9004	[illegible]	.8838	[illegible]

ACCELERATION IN YAW



$T_{X_{max}}$	=	759	lb.
$T_{Y_{max}}$	=	759	lb.
X_{rtr}	=	130	ft.
Y_{rtr}	=	154	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	21,567,000	sl.ft.^{2}
X_{TR}	=	32	ft.

DESIGN NO. D-130/.85

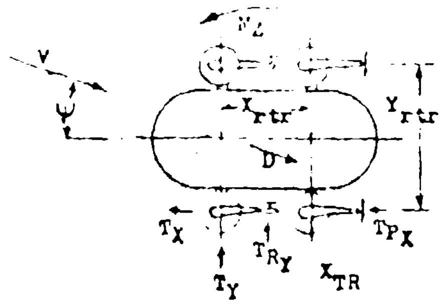
Ψ = 90 Degrees

$c_1 = 2Y_{rtr} T_{X_{max}} + 2\left(X_{rtr} T_{Y_{max}} + X_{TR} T_{R_{Y_{max}}}\right) =$ 479,112 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	6,164	17,104	33,563
Aero.Yawing Mom. ($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$g_1 = \frac{D \sin \Psi}{4}$	lb.	0	1,541	4,276	8,390
$g_2 = Y_{rtr} \frac{D \cos \Psi}{2}$	ft.lb.	0	0	0	0
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	759	759	759
$T_{R_{Y_1}}$	lb.	0	1,564	7,034	15,262
$g_3 = c_1 - g_2 - 2X_{rtr} T_{Y_1} - 2\,X_{TR} T_{R_{Y_1}}$	ft.lb.	479,112	181,676	-168,404	-594,996
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr} T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
428	.030	rad./sec.^{2}	.0253	.0155	-.0048	-.0245
1,785	.125	rad./sec.^{2}	.0350	.0212	.0049	-.0148
7,140	.500	rad./sec.^{2}	.0732	.0510	.0432	.0234
14,280	1.000	rad./sec.^{2}	.1242	.1104	.0952	.0744

ACCELERATION IN YAW



$T_{X_{max}}$	=	2,763	lb.
$T_{Y_{max}}$	=	2,763	lb.
X_{rtr}	=	130	ft.
Y_{rtr}	=	154	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	23,298,000	sl.ft.^{2}
X_{TR}	=	32	ft.

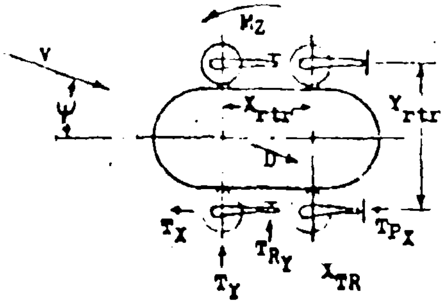
DESIGN NO. B-130/.609

Ψ = 90 Degrees

$c_1 = 2Y_{rtr}\, T_{X_{max}} + 2\left(X_{rtr}\, T_{Y_{max}} + X_{TR}\, T_{R_{Y_{max}}}\right) =$ 1,617,384 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	6,195	17,189	33,729
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$g_1 = \frac{D \sin\Psi}{4}$	lb.	0	1,548	4,297	8,432
$g_2 = Y_{rtr} \frac{D \cos\Psi}{2}$	ft.lb.	0	0	0	0
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	1,548	2,763	2,763
$T_{R_{Y_1}}$	lb.	0	0	3,068	11,338
$g_3 = c_1 - g_2 - 2X_{rtr}\, T_{Y_1} - 2\, X_{TR}\, T_{R_{Y_1}}$	ft.lb.	1,617,384	1,214,904	702,652	173,372
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\, T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				
$T_{P_{X_{max}}}$ (lb) $\quad T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560 $\quad$ .030	rad./sec.^{2}	.0797	.06.5	.0405	.0177
6,500 $\quad$ .125	rad./sec.^{2}	.1124	.0951	.0731	.0504
26,000 $\quad$ .500	rad./sec.^{2}	.2413	.2240	.2020	.1793
52,000 $\quad$ 1.000	rad./sec.^{2}	.4131	.3959	.3739	.3512

ACCELERATION IN YAW



$T_{X_{max}}$ = 10,470 lb.

$T_{Y_{max}}$ = 10,470 lb.

X_{rtr} = 130 ft.

Y_{rtr} = 154 ft.

$T_{RY_{max}}$ = 750 lb.

I_Z = 52,688,000 sl.ft.^{2}

X_{TR} = 32 ft.

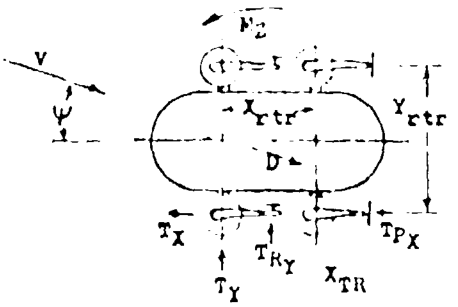
DESIGN NO. B-130/.291

ψ = 90 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2\left(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}\right) = 5{,}994{,}960$ ft.lb.

Velocity (V)		kt.	0	15	25	35
Drag (D)		lb.	0	6,696	18,580	36,458
Aero.Yawing Mom.($M_{Z_{trim}}$)		ft.lb.	0	0	0	0
$g_1 = \frac{D \sin\psi}{4}$		lb.	0	1,674	4,645	9,114
$g_2 = Y_{rtr}\,\frac{D\cos\psi}{2}$		ft.lb.	0	0	0	0
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$						
T_{Y_1}		lb.	0	1,674	4,645	9,114
$T_{R_{Y_1}}$		lb.	0	0	0	0
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$		ft.lb.	5,994,960	5,559,720	4,787,260	3,625,320
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$		$\frac{rad.}{sec.^2}$				
$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
5,910	.030	$\frac{rad.}{sec.^2}$	.1311	.1228	.1081	.0861
24,600	.125	$\frac{rad.}{sec.^2}$	.1857	.1774	.1628	.1407
98,520	.500	$\frac{rad.}{sec.^2}$	.4017	.3935	.3788	.3568
197,040	1.000	$\frac{rad.}{sec.^2}$	.6987	.6814	.6668	.6447

ACCELERATION IN YAW



$T_{X_{max}}$	=	759	lb.
$T_{Y_{max}}$	=	759	lb.
X_{rtr}	=	18[illegible]	ft.
Y_{rtr}	=	1[illegible]7	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	27,007,000	sl.ft.^{2}
X_{TR}	=	59	ft.

DESIGN NO. A-184/.85

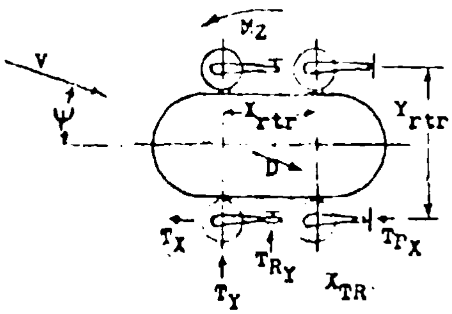
Ψ = 90 Degrees

$c_1 = 2Y_{rtr}\, T_{X_{max}} + 2\left(X_{rtr}\, T_{Y_{max}} + X_{TR}\, T_{R_{Y_{max}}}\right) =$ 575,778 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	6,374	17,687	34,707
Aero.Yawing Mom. ($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$g_1 = \frac{D \sin\Psi}{4}$	lb.	0	1,593	4,421	8,676
$g_2 = Y_{rtr}\,\frac{D \cos\Psi}{2}$	ft.lb.	0	0	0	0
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	759	759	759
$T_{R_{Y_1}}$	lb.	0	1,668	7,324	15,834
$g_3 = c_1 - g_2 - 2X_{rtr}\, T_{Y_1} - 2\, X_{TR}\, T_{R_{Y_1}}$	ft.lb.	575,778	99,642	-567,766	-1,571,946
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\, T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
428	.030	rad./sec.^{2}	.0235	.0059	-.0189	-.0560
1,7[illegible]	.125	rad./sec.^{2}	.0304	.0127	-.01[illegible]0	-.0[illegible]92
7,140	.500	rad./sec.^{2}	.0575	.0399	.0152	-.02[illegible]0
[illegible],[illegible]00	1.000	rad./sec.^{2}	.0938	.0761	.0514	.014[illegible]

ACCELERATION IN YAW



$T_{X_{max}}$	=	2,763	lb.
$T_{Y_{max}}$	=	2,763	lb.
X_{rtr}	=	184	ft.
Y_{rtr}	=	137	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	29,940,000	sl.ft.^{2}
X_{TR}	=	59	ft.

DESIGN NO. A-184/.609

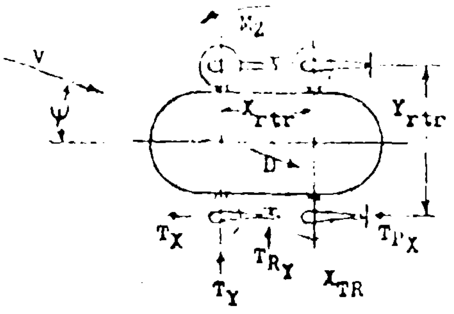
Ψ = 90 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2\left(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}\right) = 1{,}862{,}346$ ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	6,466	17,942	35,206
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$g_1 = \frac{D \sin\Psi}{4}$	lb.	0	1,616	4,485	8,801
$g_2 = Y_{rtr}\,\frac{D\cos\Psi}{2}$	ft.lb.	0	0	0	0
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	1,616	2,763	2,763
$T_{R_{Y_1}}$	lb.	0	0	3,444	12,076
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$	ft.lb.	1,862,346	1,267,658	439,170	-579,406
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560	.030	rad./sec.^{2}	.0693	.0495	.0218	-.0122
6,500	.125	rad./sec.^{2}	.0919	.0721	.0444	.0103
26,000	.500	rad./sec.^{2}	.1812	.1613	.1336	.0996
52,000	1.000	rad./sec.^{2}	.3001	.2802	.2526	.2186

ACCELERATION IN YAW



$T_{X_{max}}$	=	10,470	lb.
$T_{Y_{max}}$	=	10,470	lb.
X_{rtr}	=	184	ft.
Y_{rtr}	=	137	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	69,575,000	sl.ft.^{2}
X_{TR}	=	59	ft.

DESIGN NO. A-1[illegible]/.2[illegible]1

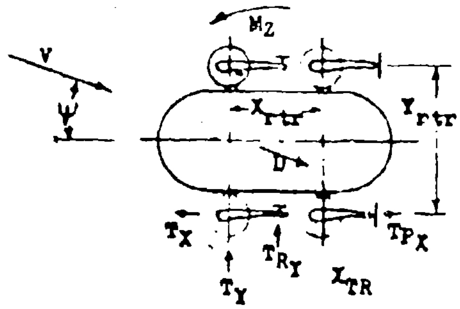
Ψ = 90 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2\left(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}\right) = 6{,}810{,}240$ ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	6,901	19,150	37,577
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$\varepsilon_1 = \frac{D \sin \Psi}{4}$	lb.	0	1,725	4,787	9,394
$\varepsilon_2 = Y_{rtr} \frac{D \cos \Psi}{2}$	ft.lb.	0	0	0	0
If $\varepsilon_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(\varepsilon_1 - T_{Y_{max}})$ $\varepsilon_1 \leq T_{Y_{max}}$, $T_{Y_1} = \varepsilon_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	1,725	4,537	9,394
$T_{R_{Y_1}}$	lb.	0	0	0	0
$\varepsilon_3 = c_1 - \varepsilon_2 - 2X_{rtr}\,T_{Y_1} - 2X_{TR}\,T_{R_{Y_1}}$	ft.lb.	6,810,240	6,175,440	5,140,624	3,353,248
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{\varepsilon_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}} / T_{total}$		$\dot{r}$			
5,910	.030	rad./sec.^{2}	.1095	[illegible]	.0855	.0598
24,600	.125	rad./sec.^{2}	.1463	.1372	.1223	.0966
98,520	.500	rad./sec.^{2}	.2919	[illegible]	.2679	.2422
[illegible]	1.000	rad./sec.^{2}	.4859	.4763	.4619	.4362

ACCELERATION IN YAW



$T_{X_{max}}$	=	759	lb.
$T_{Y_{max}}$	=	759	lb.
X_{rtr}	=	76	ft.
Y_{rtr}	=	163	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	17,645,000	sl.ft.^{2}
X_{TR}	=	5	ft.

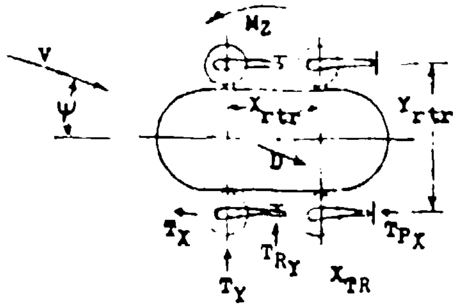
DESIGN NO. C-76/.85-609

ψ = 0 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}) =$ 370,302 ft.lb.

Velocity (V)		kt.	0	15	25	35
Drag (D)		lb.	0	866	2,402	4,713
Aero.Yawing Mom.($M_{Z_{trim}}$)		ft.lb.	0	0	0	0
$g_1 = \frac{D \sin\psi}{4}$		lb.	0	0	0	0
$g_2 = Y_{rtr}\,\frac{D\cos\psi}{2}$		ft.lb.	0	70,579	195,763	384,109
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$						
T_{Y_1}		lb.	0	0	0	0
$T_{R_{Y_1}}$		lb.	0	0	0	0
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$		ft.lb.	370,302	299,723	174,539	-13,807
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$		$\frac{\text{rad.}}{\text{sec.}^2}$				
$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560	.109	$\frac{\text{rad.}}{\text{sec.}^2}$	.0354	.0314	.0243	.0136
6,500	.455	$\frac{\text{rad.}}{\text{sec.}^2}$	.0810	.0770	.0699	.0593
26,000	1.821	$\frac{\text{rad.}}{\text{sec.}^2}$	.2612	.2572	.2500	.239
52,000	3.641	$\frac{\text{rad.}}{\text{sec.}^2}$	.5013	.4973	.4903	.4796

ACCELERATION IN YAW



$T_{X_{max}}$	=	759	lb.
$T_{Y_{max}}$	=	759	lb.
X_{rtr}	=	76	ft.
Y_{rtr}	=	163	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	17,645,000	sl.ft.^{2}
X_{TR}	=	5	ft.

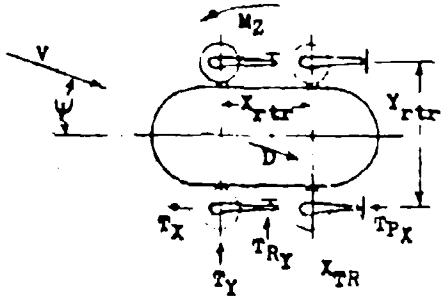
DESIGN NO. C-76/.85-.609

Ψ = 30 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}) =$ 370,302 ft.lb.

Velocity (V)		kt.	0	15	25	35
Drag (D)		lb.	0	2,582	7,166	14,061
Aero.Yawing Mom.($M_{Z_{trim}}$)		ft.lb.	0	272,838	757,882	1,485,449
$g_1 = \frac{D \sin\Psi}{4}$		lb.	0	322	895	1,757
$g_2 = Y_{rtr}\,\frac{D \cos\Psi}{2}$		ft.lb.	0	182,240	505,783	992,440
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$						
T_{Y_1}		lb.	0	322	759	759
$T_{R_{Y_1}}$		lb.	0	0	272	1,996
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2X_{TR}\,T_{R_{Y_1}}$		ft.lb.	370,302	139,118	-253,569	-757,466
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$		$\frac{rad.}{sec.^2}$				
$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560	.109	$\frac{rad.}{sec.^2}$	.03540	.006833	-.04291	-.1127
6,500	.455	$\frac{rad.}{sec.^2}$	.08103	.05247	.002723	-.06707
26,000	1.821	$\frac{rad.}{sec.^2}$	.2612	.2326	.1829	.1131
52,000	3.641	$\frac{rad.}{sec.^2}$	.5013	.4728	.4230	.3533

ACCELERATION IN YAW



$T_{X_{max}}$	=	759	lb.
$T_{Y_{max}}$	=	759	lb.
X_{rtr}	=	76	ft.
Y_{rtr}	=	163	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	17,645,000	sl.ft.^{2}
X_{TR}	=	5	ft.

DESIGN NO. C-76/.85-.609

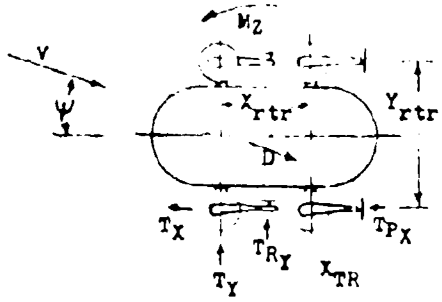
ψ = 45 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}) =$ 370,302 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.		4,030	11,194	
Aero, Yawing Mom. ($M_{Z_{trim}}$)	ft.lb.		315,050	875,138	
$g_1 = \frac{D \sin\psi}{4}$	lb.		712.41	1978.8	
$g_2 = Y_{rtr}\,\frac{D\cos\psi}{2}$	ft.lb.		232,246	645,101	
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.		712.41	759	
$T_{R_{Y_1}}$	lb.		0	2,440	
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2X_{TR}\,T_{R_{Y_1}}$	ft.lb.		29769.7	-414,567	
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	$\frac{\text{rad.}}{\text{sec.}^2}$				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
428	.030	$\frac{\text{rad.}}{\text{sec.}^2}$		-.0122	-.0691	
1,785	.125	$\frac{\text{rad.}}{\text{sec.}^2}$		.0003216	-.0566	
1,560	.109	$\frac{\text{rad.}}{\text{sec.}^2}$		-.001757	-.05868	
6,500	.455	$\frac{\text{rad.}}{\text{sec.}^2}$		.04388	-.01305	

ACCELERATION IN YAW



$T_{X_{max}}$	= 759	lb.
$T_{Y_{max}}$	= 759	lb.
X_{rtr}	= 76	ft.
Y_{rtr}	= 163	ft.
$T_{RY_{max}}$	= 750	lb.
I_Z	= 17,645,000	sl.ft.^{2}
X_{TR}	= 5	ft.

DESIGN NO. C-76/.85-.609

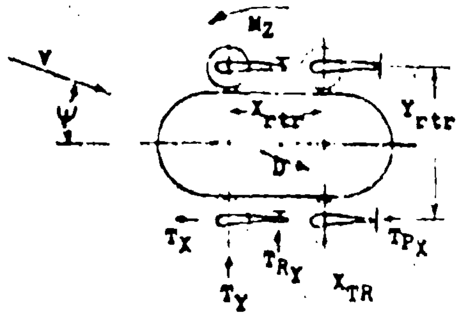
ψ = 60 Degrees

$c_1 = 2Y_{rtr}\, T_{X_{max}} + 2(X_{rtr}\, T_{Y_{max}} + X_{TR}\, T_{R_{Y_{max}}}) =$ 370,302 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	5,107	14,172	27,810
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,882	1,485,469
$g_1 = \frac{D \sin\psi}{4}$	lb.	0	1,105	3,068	6,021
$g_2 = Y_{rtr}\, \frac{D \cos\psi}{2}$	ft.lb.	0	208,110	577,509	1,133,257
If $g_1 \geq T_{Y_{max}},\ T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(g_1 - T_{Y_{max}})$; $g_1 \leq T_{Y_{max}},\ T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	759	759	759
$T_{R_{Y_1}}$	lb.	0	692	4,618	10,524
$g_3 = c_1 - g_2 - 2X_{rtr}\, T_{Y_1} - 2X_{TR}\, T_{R_{Y_1}}$	ft.lb.	370,302	39,604	-368,755	-983,563
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\, T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	$\frac{\text{rad.}}{\text{sec.}^2}$				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560	.109	$\frac{\text{rad.}}{\text{sec.}^2}$	.03540	.001193	-.04944	-.1255
6,500	.455	$\frac{\text{rad.}}{\text{sec.}^2}$	.08130	.04683	-.003805	-.07988
26,000	1.821	$\frac{\text{rad.}}{\text{sec.}^2}$	.2612	.2270	.1763	.1003
52,000	3.641	$\frac{\text{rad.}}{\text{sec.}^2}$	.5013	.4671	.4165	.3404

ACCELERATION IN YAW



$T_{X_{max}}$	=	759	lb.
$T_{Y_{max}}$	=	759	lb.
X_{rtr}	=	76	ft.
Y_{rtr}	=	163	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	17,645,000	sl.ft.^{2}
X_{TR}	=	5	ft.

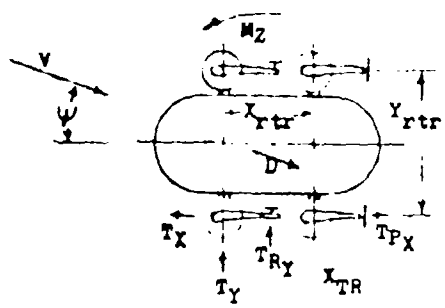
DESIGN NO. C-76/.85-.609

ψ = 90 Degrees

$c_1 = 2Y_{rtr}\, T_{X_{max}} + 2(X_{rtr}\, T_{Y_{max}} + X_{TR}\, T_{R_{Y_{max}}}) =$ 370,302 ft.lb.

Velocity (V)		kt.	0	15	25	35
Drag (D)		lb.	0	5,958	16,532	32,440
Aero.Yawing Mom. ($M_{Z_{trim}}$)		ft.lb.	0	0	0	0
$\varepsilon_1 = \frac{D \sin\psi}{4}$		lb.	0	1,489	4,133	8,110
$\varepsilon_2 = Y_{rtr} \frac{D \cos\psi}{2}$		ft.lb.	0	0	0	0
If $\varepsilon_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(\varepsilon_1 - T_{Y_{max}})$ $\varepsilon_1 \leq T_{Y_{max}}$, $T_{Y_1} = \varepsilon_1$ and $T_{R_{Y_1}} = 0$						
T_{Y_1}		lb.	0	759	759	759
$T_{R_{Y_1}}$		lb.	0	1,460	6,748	14,702
$\varepsilon_3 = c_1 - \varepsilon_2 - 2X_{rtr}\, T_{Y_1} - 2\, X_{TR}\, T_{R_{Y_1}}$		ft.lb.	370,302	240,334	187,454	107,914
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{\varepsilon_3 + Y_{rtr}\, T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$		$\frac{\text{rad.}}{\text{sec.}^2}$				
$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}} / T_{Z_{total}}$		$\dot{r}$			
1,560	.109	$\frac{\text{rad.}}{\text{sec.}^2}$	.03540	.02803	.02503	.02053
6,500	.455	$\frac{\text{rad.}}{\text{sec.}^2}$	.08103	.07367	.07067	.06616
26,000	1.821	$\frac{\text{rad.}}{\text{sec.}^2}$	.2612	.2538	.2508	.2463
52,000	3.641	$\frac{\text{rad.}}{\text{sec.}^2}$	.5013	.4940	.4910	.4865

ACCELERATION IN YAW



$T_{X_{max}}$ = 759 lb.

$T_{Y_{max}}$ = 759 lb.

X_{rtr} = 130 ft.

Y_{rtr} = 154 ft.

$T_{RY_{max}}$ = 750 lb.

I_Z = 21,567,000 sl.ft.^{2}

X_{TR} = 32 ft.

DESIGN NO. B0130/.85-.609

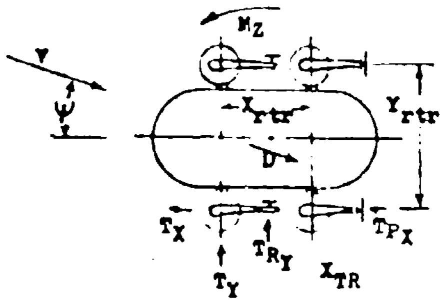
Ψ = 0 Degrees

$c_1 = 2X_{rtr}\,T_{X_{max}} + 2(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}) =$ 479,112 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	887	2,461	4,830
Aero.Yawing Mom. ($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$g_1 = \frac{D \sin\Psi}{4}$	lb.	0	0	0	0
$g_2 = Y_{rtr}\,\frac{D\cos\Psi}{2}$	ft.lb.	0	68,299	189,497	371,910
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	0	0	0
$T_{R_{Y_1}}$	lb.	0	0	0	0
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$	ft.lb.	479,112	410,813	289,615	107,202
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560	.109	rad./sec.^{2}	.03335	.03019	.02457	.01611
6,500	.455	rad./sec.^{2}	.06863	.06546	.05984	.05139
26,000	1.821	rad./sec.^{2}	.2079	.2047	.1991	.1906
52,000	3.641	rad./sec.^{2}	.3935	.3904	.3847	.3763

ACCELERATION IN YAW



$T_{X_{max}}$	=	759	lb.
$T_{Y_{max}}$	=	759	lb.
X_{rtr}	=	130	ft.
Y_{rtr}	=	154	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	21,567,000	sl.f .^{2}
X_{TR}	=	32	ft.

DESIGN NO. B-130/.85-.609

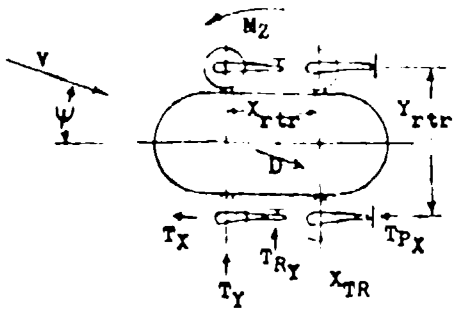
ψ = 30 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}})$ = 479,112 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	2,636	7,314	14,352
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,882	1,485,449
$g_1 = \frac{D \sin\psi}{4}$	lb.	0	329	914	1,794
$g_2 = Y_{rtr}\,\frac{D \cos\psi}{2}$	ft.lb.	0	175,778	487,726	957,048
If $g_1 \geq T_{Y_{max}},\ T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}},\ T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	329	759	759
$T_{R_{Y_1}}$	lb.	0	0	310	2,070
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$	ft.lb.	479,112	217,794	-225,794	-807,756
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}} / T_{Z_{total}}$		$\dot{r}$			
1,560	.109	rad./sec.^{2}	.03335	.08587	-.03447	-.09519
6,500	.455	rad./sec.^{2}	.06863	.04386	.0008032	-.6627
26,000	1.821	rad./sec.^{2}	.2079	.1831	.1405	.07932
52,000	3.641	rad./sec.^{2}	.3935	.3688	.3257	.2650

ACCELERATION IN YAW



$T_{X_{max}}$	=	759	lb.
$T_{Y_{max}}$	=	759	lb.
X_{rtr}	=	130	ft.
Y_{rtr}	=	154	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	21,567,000	sl.ft.^{2}
X_{TR}	=	32	ft.

DESIGN NO. B-130/.85-.609

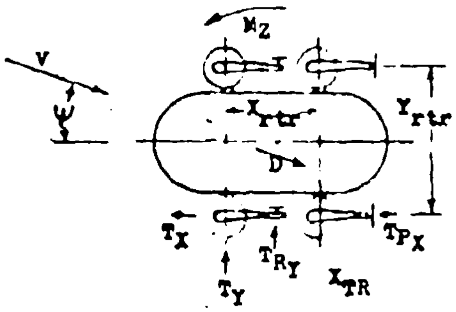
ψ = 45 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}) =$ 479,112 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.		4,100	11,389	
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.		315,050	875,138	
$g_1 = \frac{D \sin\psi}{4}$	lb.		724.78	2013.31	
$g_2 = Y_{rtr}\,\frac{D \cos\psi}{2}$	ft.lb.		223,234	620,099	
If $g_1 \geq T_{Y_{max}},\ T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}},\ T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.		724.78	759	
$T_{R_{Y_1}}$	lb.		0	2,509	
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$	ft.lb.		67,435	-498,903	
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,428	.030	rad./sec.^{2}		-.0084	-.0607	
1,785	.125	rad./sec.^{2}		+.0013	-.0510	
1,560	.109	rad./sec.^{2}		-.0003	-.0526	
6,500	.455	rad./sec.^{2}		.0349	-.0173	

ACCELERATION IN YAW



$T_{X_{max}}$	=	759	lb.
$T_{Y_{max}}$	=	759	lb.
X_{rtr}	=	130	ft.
Y_{rtr}	=	154	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	21,567,000	sl.ft.^{2}
X_{TR}	=	32	ft.

DESIGN NO. B-130/.85-.609

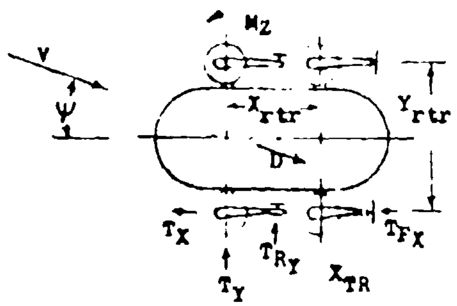
ψ = 60 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}) =$ 479,112 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	5,249	14,564	28,579
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,882	1,485,449
$g_1 = \frac{D \sin \psi}{4}$	lb.	0	1,136	3,153	6,187
$g_2 = Y_{rtr}\,\frac{D \cos \psi}{2}$	ft.lb.	0	202,086	560,714	1,100,291
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	759	759	759
$T_{R_{Y_1}}$	lb.	0	754	4,788	10,856
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$	ft.lb.	479,112	31,430	-226,746	-615,098
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	$\frac{\text{rad.}}{\text{sec.}^2}$				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560	.109	$\frac{\text{rad.}}{\text{sec.}^2}$	.03335	-.0000541	-.03452	-.08626
6,500	.455	$\frac{\text{rad.}}{\text{sec.}^2}$	.06863	.0352	.0007591	-.0510
26,000	1.821	$\frac{\text{rad.}}{\text{sec.}^2}$	.2079	.1745	.1340	.08826
52,000	3.641	$\frac{\text{rad.}}{\text{sec.}^2}$	.3935	.3601	.3257	.2739

ACCELERATION IN YAW



$T_{X_{max}}$ = 759 lb.

$T_{Y_{max}}$ = 759 lb.

X_{rtr} = 130 ft.

Y_{rtr} = 154 ft.

$T_{RY_{max}}$ = 750 lb.

I_Z = 21,567,000 sl.ft.^{2}

X_{TR} = 32 ft.

DESIGN NO. B-130/.85-.609

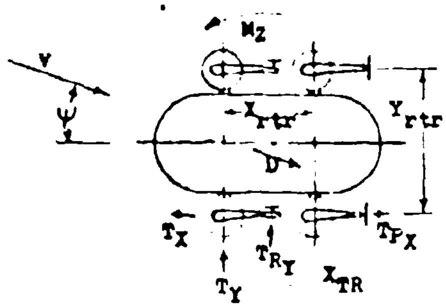
ψ = 90 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}) =$ 479,112 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	6,154	17,104	33,563
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$\varepsilon_1 = \dfrac{D \sin\psi}{4}$	lb.	0	1,541	4,276	6,390
$\varepsilon_2 = Y_{rtr}\,\dfrac{D\cos\psi}{2}$	ft.lb.	0	0	0	0
If $\varepsilon_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(\varepsilon_1 - T_{Y_{max}})$ $\varepsilon_1 \leq T_{Y_{max}}$, $T_{Y_1} = \varepsilon_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	759	759	759
$T_{R_{Y_1}}$	lb.	0	1,564	7,034	15,262
$\varepsilon_3 = c_1 - \varepsilon_2 - 2X_{rtr}\,T_{Y_1}$ $-2\,X_{TR}\,T_{R_{Y_1}}$	ft.lb.	479,112	181,676	-168,404	-594,996
$\dot{r} = \dfrac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z}$ $= \dfrac{\varepsilon_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560	.109	rad./sec.^{2}	.03335	.01956	.003331	-.01645
6,500	.455	rad./sec.^{2}	.06863	.05484	.03861	.01883
26,000	1.821	rad./sec.^{2}	.2079	.1941	.1778	.1581
52,000	3.641	rad./sec.^{2}	.3935	.3797	.3635	.3437

ACCELERATION IN YAW



$T_{X_{max}}$ = 759 lb.

$T_{Y_{max}}$ = 759 lb.

X_{rtr} = 184 ft.

Y_{rtr} = 137 ft.

$T_{RY_{max}}$ = 750 lb.

I_Z = 27,007,000 sl.ft.^{2}

X_{TR} = 59 ft.

DESIGN NO. A-184/.85-.609

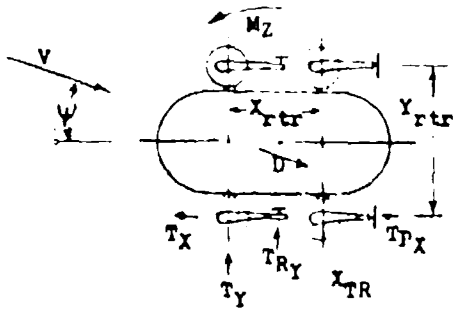
ψ = 0 Degrees

$c_1 = 2Y_{rtr}\, T_{X_{max}} + 2(X_{rtr}\, T_{Y_{max}} + X_{TR}\, T_{R_{Y_{max}}}) =$ 575,778 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	898	2,493	4,892
Aero.Yawing Mom. ($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$\varepsilon_1 = \frac{D \sin\psi}{4}$	lb.	0	0	0	0
$\varepsilon_2 = Y_{rtr}\, \frac{D \cos\psi}{2}$	ft.lb.	0	61,513	170,770	335,102
If $\varepsilon_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(\varepsilon_1 - T_{Y_{max}})$ $\varepsilon_1 \leq T_{Y_{max}}$, $T_{Y_1} = \varepsilon_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	0	0	0
$T_{R_{Y_1}}$	lb.	0	0	0	0
$\varepsilon_3 = c_1 - \varepsilon_2 - 2X_{rtr}\, T_{Y_1} - 2\, X_{TR}\, T_{R_{Y_1}}$	ft.lb.	575,778	514,265	405,008	240,676
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{\varepsilon_3 + Y_{rtr}\, T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560	.109	rad./sec.^{2}	.02923	.02696	.02291	.01683
6,500	.455	rad./sec.^{2}	.05429	.05201	.04797	.04188
26,000	1.821	rad./sec.^{2}	.1532	.1509	.1469	.1408
52,000	3.641	rad./sec.^{2}	.2851	.2828	.2788	.2727

ACCELERATION IN YAW



$T_{X_{max}}$	=	759	lb.
$T_{Y_{max}}$	=	759	lb.
X_{rtr}	=	184	ft.
Y_{rtr}	=	137	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	27,007,000	sl.ft.^{2}
X_{TR}	=	59	ft.

DESIGN NO. A-184/.85-.609

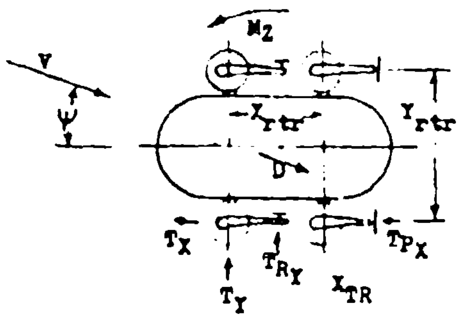
ψ = 30 Degrees

$c_1 = 2Y_{rtr}\, T_{X_{max}} + 2(X_{rtr}\, T_{Y_{max}} + X_{TR}\, T_{R_{Y_{max}}}) =$ 575,778 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	2,705	7,505	14,726
Aero.Yawing Mom.($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,882	1,485,449
$\varepsilon_1 = \frac{D \sin\psi}{4}$	lb.	0	338	938	1,840
$\varepsilon_2 = Y_{rtr}\frac{D\cos\psi}{2}$	ft.lb.	0	160,460	445,217	873,586
If $\varepsilon_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(\varepsilon_1 - T_{Y_{max}})$ $\varepsilon_1 \leq T_{Y_{max}}$, $T_{Y_1} = \varepsilon_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	338	759	759
$T_{R_{Y_1}}$	lb.	0	0	358	2,162
$\varepsilon_3 = c_1 - \varepsilon_2 - 2X_{rtr}\, T_{Y_1} - 2\, X_{TR}\, T_{R_{Y_1}}$	ft.lb.	575,778	290,926	-190,995	-832,236
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{\varepsilon_3 + Y_{rtr}\, T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	$\frac{rad.}{sec.^2}$				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560	.109	$\frac{rad.}{sec.^2}$	.02923	.008583	-.0272	-.07790
6,500	.455	$\frac{rad.}{sec.^2}$	.05430	.03364	-.002162	-.05285
26,000	1.821	$\frac{rad.}{sec.^2}$	.1532	.1326	.09676	.04607
52,000	3.641	$\frac{rad.}{sec.^2}$	.2851	.2645	.2286	.1780

ACCELERATION IN YAW



$T_{X_{max}}$	=	759	lb.
$T_{Y_{max}}$	=	759	lb.
X_{rtr}	=	184	ft.
Y_{rtr}	=	137	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	27,007,000	sl.ft.^{2}
X_{TR}	=	59	ft.

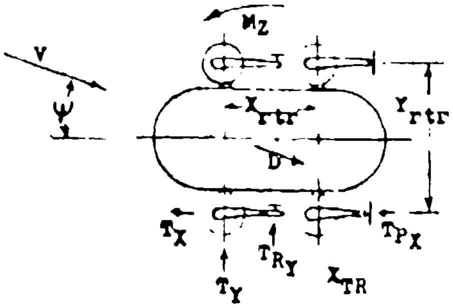
DESIGN NO. A-104/.05-.609

ψ = 45 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2(X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}) =$ 575,778 ft.lb.

Velocity (V)		kt.	0	15	25	35
Drag (D)		lb.		4,300	11,944	
Aero.Yawing Mom.($M_{Z_{trim}}$)		ft.lb.		315,050	875,138	
$g_1 = \dfrac{D \sin\psi}{4}$		lb.		760.14	2,111.4	
$g_2 = Y_{rtr}\,\dfrac{D \cos\psi}{2}$		ft.lb.		208,278	578,529	
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$						
T_{Y_1}		lb.		759	759	
$T_{R_{Y_1}}$		lb.		2.28	2,705	
$g_3 = c_1 - g_2 - 2Y_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$		ft.lb.		87,919	-601253	
$\dot{r} = \dfrac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \dfrac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$		$\frac{\text{rad.}}{\text{sec.}^2}$				
$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$			$\dot{r}$		
428	.030	$\frac{\text{rad.}}{\text{sec.}^2}$		.2890	-.05250	
1,785	.125	$\frac{\text{rad.}}{\text{sec.}^2}$		.0006448	-.04561	
1,560	.109	$\frac{\text{rad.}}{\text{sec.}^2}$		-.0004966	-.04676	
6,500	.455	$\frac{\text{rad.}}{\text{sec.}^2}$		.02456	-.02169	

ACCELERATION IN YAW



$T_{X_{max}}$	=	759	lb.
$T_{Y_{max}}$	=	759	lb.
X_{rtr}	=	184	ft.
Y_{rtr}	=	137	ft.
$T_{RY_{max}}$	=	750	lb.
I_Z	=	27,007,000	sl.ft.^{2}
X_{TR}	=	59	ft.

DESIGN NO. A-184/.85-.609

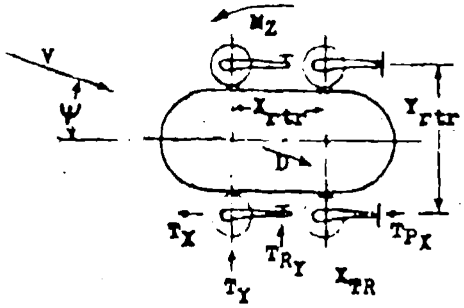
Ψ = 60 Degrees

$c_1 = 2Y_{rtr}\, T_{X_{max}} + 2(X_{rtr}\, T_{Y_{max}} + X_{TR}\, T_{R_{Y_{max}}}) =$ 575,778 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	5,447	15,116	29,661
Aero.Yawing Mom. ($M_{Z_{trim}}$)	ft.lb.	0	272,838	757,882	1,485,449
$g_1 = \frac{D \sin\Psi}{4}$	lb.	0	1,179	3,272	6,421
$g_2 = Y_{rtr}\, \frac{D \cos\Psi}{2}$	ft.lb.	0	186,559	517,723	1,015,889
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	759	759	759
$T_{R_{Y_1}}$	lb.	0	840	5,026	11,324
$g_3 = c_1 - g_2 - 2X_{rtr}\, T_{Y_1} - 2X_{TR}\, T_{R_{Y_1}}$	ft.lb.	575,778	10,787	-814,325	-2,055,655
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\, T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{P_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560	.109	rad./sec.^{2}	.02923	-.001790	-.0503	-.1232
6,500	.455	rad./sec.^{2}	.05429	.02327	-.02524	-.09815
26,000	1.821	rad./sec.^{2}	.1782	.1222	.07368	.0007737
52,000	3.641	rad./sec.^{2}	.2851	.2541	.2056	.1327

ACCELERATION IN YAW



$T_{X_{max}}$ = 759 lb.
$T_{Y_{max}}$ = 759 lb.
X_{rtr} = 184 ft.
Y_{rtr} = 137 ft.
$T_{RY_{max}}$ = 750 lb.
I_Z = 27,007,000 sl.ft.^{2}
X_{TR} = 59 ft.

DESIGN NO. A-184/.85-.609

ψ = 90 Degrees

$c_1 = 2Y_{rtr}\,T_{X_{max}} + 2\,X_{rtr}\,T_{Y_{max}} + X_{TR}\,T_{R_{Y_{max}}}$ = 575,778 ft.lb.

Velocity (V)	kt.	0	15	25	35
Drag (D)	lb.	0	6,374	17,687	34,707
Aero.Yawing Mom. ($M_{Z_{trim}}$)	ft.lb.	0	0	0	0
$g_1 = \frac{D \sin\psi}{4}$	lb.	0	1,593	4,421	8,626
$g_2 = Y_{rtr}\,\frac{D \cos\psi}{2}$	ft.lb.	0	0	0	0
If $g_1 \geq T_{Y_{max}}$, $T_{Y_1} = T_{Y_{max}}$ and $T_{R_{Y_1}} = 2\,(g_1 - T_{Y_{max}})$ $g_1 \leq T_{Y_{max}}$, $T_{Y_1} = g_1$ and $T_{R_{Y_1}} = 0$					
T_{Y_1}	lb.	0	759	759	759
$T_{R_{Y_1}}$	lb.	0	1,668	7,324	15,834
$g_3 = c_1 - g_2 - 2X_{rtr}\,T_{Y_1} - 2\,X_{TR}\,T_{R_{Y_1}}$	ft.lb.	575,778	99,642	-567,766	-1,571,946
$\dot{r} = \frac{M_{Z_{max}} - M_{Z_{trim}}}{I_Z} = \frac{g_3 + Y_{rtr}\,T_{P_{X_{max}}} - M_{Z_{trim}}}{I_Z}$	rad./sec.^{2}				

$T_{R_{X_{max}}}$ (lb)	$T_{P_{X_{max}}}/T_{Z_{total}}$		$\dot{r}$			
1,560	.109	rad./sec.^{2}	.02923	.01161	-.01311	-.05029
6,500	.455	rad./sec.^{2}	.05429	.03666	.01195	-.02523
26,000	1.821	rad./sec.^{2}	.1532	.1356	.1109	.07369
52,000	3.641	rad./sec.^{2}	.2851	.2675	.2428	.2056

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